A User Guide To

PIT & QUARRY RECLAMATION IN ALBERTA

By

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Preface

A User Guide to Pit and Quarry Reclamation is intended as a companion document to the *Sand and Gravel Manual: How to Apply for Development and Reclamation Approval*, which can be obtained through:

Alberta Environment
Land Reclamation Division,
Development and Reclamation Review Branch
3rd Floor, Oxbridge Place
9820-106th Street
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T5K 2J6
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The sand and gravel manual provides information on the minimum requirements for pits and quarries on ***private land***. Information on reclamation for pits and quarries on ***public lands*** can be obtained through:

Land Management Branch
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The Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife also have available a series of helpful pamphlets on reclaiming sand and gravel pits for fish and wildlife habitat. Contact your regional Fish and Wildlife Office, or:

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ABOUT THIS MANUAL

This manual — A USERS' GUIDE TO PIT AND QUARRY RECLAMATION IN ALBERTA — provides information on:

- the basics of material extraction and processing,
- planning of a pit or quarry operation from start-up to closure, and
- selecting the best land use or uses for your reclaimed site.

Important considerations in reclamation planning and methods for reclamation are described for six major types of land uses: agriculture, forestry, wildlife habitat, fish habitat, recreation, and residential/industrial use.

The manual is intended for use by a broad audience that includes small 'private' pits and quarries, medium-sized commercial operations, and major, long-term commercial ventures, and operators with varying degrees of experience in planning and reclaiming a pit or quarry. The manual provides an introduction to reclamation planning and methods, as well as a summary of current regulations and requirements for operations on private lands and public lands.

The manual should be used as 'catalogue' of some of the important factors you should consider in developing a pit or quarry, the types of end uses that may be suitable for your operation, and the range of reclamation methods that may help you attain your reclamation objectives. It should not be used as a comprehensive review of reclamation methods. Reclamation of pits and quarries, particularly large-scale sites, can be a complex undertaking. You are strongly encouraged to contact Alberta Environment or Alberta Forestry, Lands and Wildlife for assistance in adequately reclaiming your site. Agency contacts and phone numbers are provided in Chapter 10. Trained professionals such as agrologists, soil scientists, biologists, planners, landscape architects and engineers can also provide consulting services, often at reasonable cost.

Good planning and effective reclamation are in everyone's best interest. To operators, good planning promotes efficient and profitable extraction of the resource. Effective reclamation returns the land to other uses, some of which may provide additional financial benefits to your operation.

To you, your neighbours and the general public, good planning and reclamation ensures that land disturbances are minimized, and that disturbed areas are returned to productive use for agriculture, forestry, natural environments, recreation or residential/ industrial use as soon as possible.

For our environment, good planning reduces hazards such as water contamination, loss of topsoil, and destruction of fish and wildlife habitat, and can help ensure that your operation is environmentally sustainable. Good reclamation will hopefully result in little or no loss of such valuable natural resources as clean water, fertile soil, timber production, agriculture, fish, wildlife and scenic landscapes.

In light of the recent, rapid deterioration of our environment, and the growing concern for the future of our planet, reclamation is one way, that you as an individual or a company, can make a difference.

HOW TO USE THE MANUAL

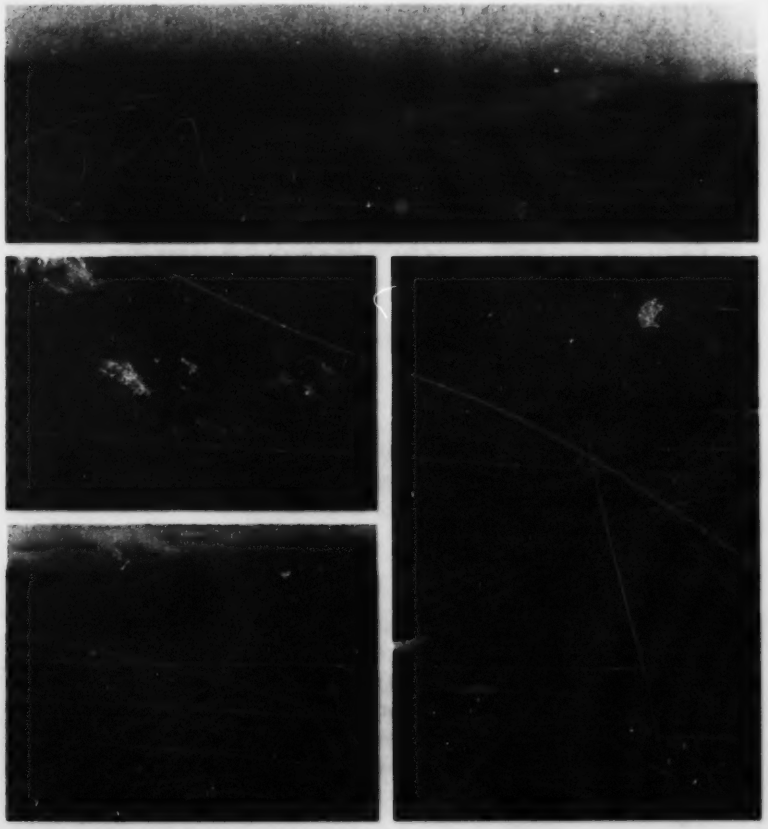
If you are unfamiliar with reclamation planning and methods for pits and quarries, you should begin by reading Chapter 1 through Chapter 3. These chapters will provide you with a background in pit and quarry operations, planning your operation, and selecting a final land use or uses for your reclamation area. Once you have decided on a preferred land use for your site (for private lands), or have obtained direction on the preferred end use from the administrating government agency (for public lands), Chapter 4 through Chapter 9 will provide you with more detailed information — specific to your selected land use — on important considerations in developing a reclamation plan for your operation, and reclamation methods.

If you are familiar with pit and quarry development and reclamation planning, you will likely only need to refer to one or more chapters that address your selected land use or uses. In light of the strong public interest in environmental issues, you may also want to review those portions of Chapter 1 that deal with important environmental considerations and the need for reclamation.

THE BASICS OF MATERIALS EXTRACTION AND PROCESSING

Chapter 1 describes the different types of extraction and processing activities that may occur as part of a pit or quarry operation in Alberta. These descriptions may be useful to you in defining specific terms, and in better understanding the range of activities in resource extraction.

More importantly, Chapter 1 describes some of the environmental concerns that everyone should consider when designing, operating and reclaiming a pit or quarry operation. Good environmental practice is important, no matter what the size of your operation. In fact, stringent environmental legislation and guidelines require all operators to minimize environmental damage.



EXTRACTION

Sand and Gravel Pits

Sand and gravel can often be extracted from the same pit, depending on the type of deposit. However, local market demand will determine if one or both of these materials will be processed.

In general, extraction and processing activities are similar for sand and gravel operations. Pit depths are variable, but do not normally exceed 5 to 7 m. Pit sizes can range from 1 to 2 ha to very large operations. Sand and gravel are relatively cheap commodities relative to their bulk, and a major cost of their supply is transportation. As a result, most sand and gravel pits are operated near construction operations such as roads, industrial sites and residential developments.

Clay and Marl Pits

Clay and marl pits are usually opened for special situations requiring such material. As clay can help reduce seepage, it is often used to line dugouts, industrial ponds or ditches. Marl, or bog lime, may be used to reduce the acidity of soils or waters.

Borrow Pits

Borrow pits, while occasionally containing some sand and gravel deposits, are most often excavated to provide non–granular fill for construction activities. Fill of this type is usually removed and then compacted on site as a base for construction. Borrow material is commonly used to construct gentle slopes at roadsides and to landscape around residential developments. Topsoil is then placed on top of the borrow, and the area is seeded to provide a vegetation cover.

Quarries

Quarries are defined as a pit or excavation for the removal, opening up or proving of minerals, other than coal or oilsands. Typical quarried products in Alberta include limestone, sandstone, shale, metallic minerals and ammonite.

TYPES OF PROCESSING OPERATIONS

Crushing

Gravels are extracted in many shapes and sizes, and many end uses require small, consistent–sized, angular gravels for construction. As most gravels are removed from the ground in smooth rounded shapes, crushing is used to provide gravel sizes which are not naturally available on a large scale. The crushing of gravels also extends the life span of the resource as large gravel aggregates which would not be otherwise useful can be put into effective use.

Screening

As many gravel and sand pits contain mixtures of both sands and gravels, they are often screened to sort the different sizes of aggregates required for construction purposes. Screening provides consistent sizes of aggregate, as well as removing sand from the gravels.

ILLUSTRATION 1, A SAND AND GRAVEL OPERATION SHOWING CRUSHING, SCREENING, WASHING AND STOCKPILING ACTIVITIES

Washing

Washing of aggregates from gravel pits typically takes place when there is a requirement for clean gravels. Finer gravels are usually washed to remove sands and other material which were accumulated during the extraction and processing phases. The waste water from the washing operation is often piped into settling ponds to allow separation of the finer materials, and recycling of the wash water. Some finer material may be collected for further processing.

Dewatering

Many gravel beds were originally deposited by glacial streams, and are now located below the present groundwater level. Mining of flooded gravel is often accomplished by dewatering, a process by which the pit is temporarily emptied of water by pumping. Shallow wells or ponds may be established in the bottom of the pit and pumps are used to keep the water level below the gravel extraction level.

Stockpiling

As the gravel or sand is excavated and processed it is frequently stored in large mounds, called stockpiles. This is especially true in long-term operations. When the demand for the resource or a particular type of aggregate is not especially high, or when more aggregate is extracted than can be used for a specific project, the excess material is stockpiled. Stockpiles should be placed where they are easily accessible for loading material into gravel trucks. Stockpiles may last from a few weeks to several years.

IMPORTANT ENVIRONMENTAL CONCERNS

Pits and quarries usually require the removal of vegetation cover and topsoil, stripping of overburden and spoil material, and development of processing and loading facilities and service areas. These activities, along with access roads, usually result in severe disturbance or complete destruction of soil, landforms and vegetation. Erosion by wind and water can result in further losses of soil and vegetation.

Although these effects are obvious to most operators, there are also a number of more subtle effects that should be considered and minimized during site development and operation:

- loss of topsoil,
- loss of plant cover,
- changes in the quality and quantity of surface water and groundwater,
- siltation of aquatic habitat,
- contamination of soil and water by spills of oil and other fluids,
- soil salinization, and
- alteration of flood plains.

ILLUSTRATION 2, SOIL EROSION, PARTICULARLY THE LOSS OF TOPSOIL, MUST BE PREVENTED DURING PIT OPERATIONS

Loss of Topsoil

As good quality topsoil can take decades to develop, it should be considered an extremely valuable, non-renewable resource. Replacement of topsoil is required to restore and maintain pre-disturbance levels of capability. You should ensure that topsoil losses ***do not occur*** during your pit operation by ***preventing***:

- poor or incomplete salvage of topsoil;
- mixing of topsoil with subsoil or overburden during salvage;
- burial of topsoil under storage areas for overburden and aggregate stockpiles;
- erosion of topsoil by wind or water during the salvage operation, from the stockpile, or after replacement;
- theft of topsoil from stockpiles;
- failure to strip topsoil from the buffer zone around the edges of the pit (Illustration 2); and
- contamination of topsoil by oil, grease and other chemicals.

In this document the material below the topsoil is called overburden. In some soils, however, the material lying just below the topsoil is of better quality than the deeper material. In these cases, especially where the end land use is agriculture, better reclamation will be achieved if this upper subsoil layer is also separately salvaged and replaced.

PHOTO 1, LOSSES OF NATIVE VEGETATION SHOULD BE MINIMIZED DURING THE DEVELOPMENT OF YOUR PIT

Loss of Plant Cover

Plant cover is an integral part of all natural habitats. Losses of trees, shrubs, and groundcovers commonly occur during stripping and stockpiling of the surface soil layers, or through burial in storage areas. Areas that are not stripped or buried may be crushed by equipment travel and other processing operations. You should try to minimize losses of existing vegetation because:

- Vegetation builds and maintains the organic content of soil. This helps develop a more open soil structure that improves the soaking in and storage of water within the root zone of plants;
- Vegetation helps establish and maintain a layer of partly decomposed organic matter at or near the surface of the soil. This prevents surface water from carrying fine soil particles, and clogging soil openings that are important to allow water to soak into the soil;
- Vegetation spreads water over the surface of the land which, in turn, helps the soil soak up surface water and reduce overland flows;
- By reducing overland flows, vegetation reduces soil erosion;
- Vegetation shades the ground and minimizes wind movement. This tends to reduce snow melt and evaporation from the soil, and helps keep your soil moist (Photo 1);
- Vegetation can moderate the climate in your local area;
- Vegetation provides hiding cover and food for thousands of organisms from the smallest insect to large animals such as moose (Photo 1);

- Vegetation provides a seed source for perpetuation of natural cover; and
- Vegetation is the first link in the food chain which provides energy for all life on earth (Photo 1).

Groundwater and Surface Water

Most pits and quarries will alter the local quality and quantity of groundwater and surface water. Water flows from the disturbed areas will often be more variable than from unmined areas. The use of heavy equipment will compact surface soils and subsoils which, in turn, reduces the soil's ability to absorb moisture, and increases overland flow. Because hard soils hinder plant establishment, surface runoff is rapid, and erosion of soils may be increased. Increased soil erosion may, in turn, reduce nearby stream quality through siltation.

Surface Drainage and Ponding

Local surface water and groundwater flow patterns can be disrupted on extraction sites. Rainfall or meltwater which does not soak into the ground or collect in small depressions, moves over the ground surface as overland flow. This movement of water gradually erodes the soil surface and, in a worst case, can create flash floods as smaller channels merge with larger channels. In undisturbed, natural areas, rainfall from most storms rarely exceeds the ability of soils and vegetation to soak up and control runoff.

ILLUSTRATION 3, MUD AND SILTS FROM PIT OPERATIONS CAN SMOTHER SPAWNING AREAS FOR FISH

Siltation

Soil disturbance and washing of aggregates can produce large volumes of mud and silts. If these materials run into natural water courses, water quality can be severely reduced. This can affect aquatic habitats in several ways:

- When sediments are carried by surface waters, water becomes turbid (muddy). Sunlight cannot penetrate and aquatic plants may not grow as well. Mayflies, stoneflies and other aquatic insects, which are important foods for fish, can be harmed by the scouring action of suspended sediments. Heavy sediments can make it difficult for some fish to feed and breath. In extreme cases, fish may move away until conditions improve.
- A second, more serious effect occurs when silts and muds settle out of the water onto the stream bed. Growth of algae (single cell plants) can be smothered, resulting in losses of foods for some insects and fish. Sediments can also fill up the spaces between stones, and eliminate hiding places for small aquatic animals.
- The most serious direct effect of sedimentation is the smothering of spawning gravels for trout and other fish (Illustration 3). These fish usually bury their eggs in riffles at the lower boundary of pools where the gravels are almost free of large rocks, boulders and fine silts. If gravels become choked with silt, eggs may not be laid or, if laid, may be smothered. If the eggs develop into fry, silt can make it difficult for young fish (fry) to emerge. Fry may also lose hiding places which enable them to escape larger fish.

PHOTO 2, DURING YOUR OPERATION, CARE SHOULD BE TAKEN TO MINIMIZE SPILLS OF OILS AND OTHER POLLUTANTS

Contaminants

Extraction activities require large equipment and processing machinery. This machinery can suffer from breakdowns and oil and hydraulic leaks (Photo 2). Spills of oil, hydraulic fluid and fuel may also occur during equipment servicing. Over time, spills and leaks can result in substantial amounts of pollutants on site. Extraction operations in certain rock types can also result in large releases of heavy metals and acids from spoil piles. Because surface flows often increase as a result of gravel extraction, and groundwater tables may be exposed, pollutants can easily enter surface water and groundwater. Such pollution can sometimes affect vegetation, wetlands, water courses and water wells far from the pit or quarry.

Soil Salinization

The soils overlying gravels are usually well drained and are not affected by salinity (often called "alkali"). There are situations, however, where due to groundwater movement, the overlying soil and overburden may have high levels of water-soluble salts. These saline soils are often sodic (high levels of sodium), and are strongly alkaline (a high pH). Pit floors quite commonly have the same problems. Some of the salts (especially the sodium salts) are very soluble and are therefore harmful to plant growth. Other salts, such as lime and gypsum "salts", are not very soluble, but they do keep soil alkaline. Soil materials with high salt levels will hinder the re-establishment of plants, and should be covered with better soils if possible. Limitations to soil quality are defined in the document Soil Quality Criteria Relative to Disturbance and Reclamation of the Alberta Soils Advisory Committee (1987), which is published by Alberta Agriculture.

PHOTO 3, SAND AND GRAVEL OPERATIONS ARE OFTEN LOCATED CLOSE TO RIVERS AND OTHER WATERCOURSES

Floodplains

Because gravels and sands are deposited along rivers and streams, many gravel and sand operations are located on or near existing floodplains (Photo 3). In order to protect these water courses, government agencies may restrict the location, size, shape and depth of nearby pits. The buffer zone around the pit may also need to be larger for river and stream protection.

Operations on floodplains must take care to prevent deposition of silt and other materials into the adjacent water channels. Seepage of waste materials such as oils and hydraulic fluids into the pit floor must be prevented as gravel and sand deposits in floodplains are often directly connected to the main river or stream by groundwater flows. Due to the risk of floods, operators must also be aware of safety concerns during snow melt, spring highwater or flash storms.

THE NEED FOR RECLAMATION

Why is reclamation of a pit or quarry necessary? First, reclamation of pits and quarries is required on all lands. Second, disturbed areas are not only unsightly, but there are numerous environmental effects that can arise from poor land management or from not reclaiming excavated areas. In many cases, these practices can result in changes in water quality, the abundance of surface water and groundwater, fish and wildlife habitat, fish and wildlife abundance, and recreational opportunities.

All of these changes affect the quality of life for you, your neighbours, and other residents.

PHOTO 4, TOPSOIL IS A VALUABLE RESOURCE THAT MUST BE PROTECTED DURING THE DEVELOPMENT OF YOUR OPERATION

Topsoil Protection

Topsoil protection requires commitment and planning. Sequential salvage and replacement of topsoil as part of an extraction operation is vital in maintaining land capability (Photo 4). Sequential replacement of topsoil also promotes better growth of plant cover, and serves as a source of native seeds, root stocks and plants that can directly benefit land uses such as wildlife habitat and recreation.

Erosion Control

As all extraction activities will result in soil disturbance and vegetation removal, reclamation is necessary to control surface erosion and sedimentation of streams, rivers and waterbodies (Photo 5). Erosion can severely scar a landscape and result in long-term setbacks to the natural recovery of vegetation. It also reduces the value of land for almost all land uses. In extreme cases, erosion can prevent the future use of the pit or quarry for agriculture, forestry, recreation, residential developments and industrial use.

Revegetation

Replanting of vegetation on a disturbed site helps to restore surface stability, site productivity and scenic values (Photo 6). Most importantly, vegetation cover reduces erosion by eliminating or slowing the flow of water over the soil surface (see "Siltation" above). The establishment of vegetation on a disturbed site improves the stability of surface soils through root development. Decaying organic material from growing and dying plants replaces lost organic matter and, over the long-term, improves plant growth. Establishment of natural communities of trees, shrubs and groundcovers also helps to blend the contours and boundaries of a disturbed site with the surrounding area.

PHOTO 5, RIP-RAP IS ONE METHOD OF CONTROLLING SOIL EROSION IN DRAINAGE CHANNELS

PHOTO 6, REVEGETATION OF DISTURBED AREAS IS IMPORTANT IN RESTORING SURFACE STABILITY, SITE PRODUCTIVITY AND SCENIC VALUES

PLANNING YOUR OPERATION

Effective planning of your operation prior to development is one of the most important tasks in successfully operating and reclaiming a pit or quarry. Good planning can save time and money by reducing the need for multiple handling of materials.

Chapter 2 describes the basic steps in planning and operating a pit or quarry operation, from site design and preparation, to obtaining approval, to closure of the pit. Highlights in this chapter include:

- Minimum reclamation requirements,
- Obtaining government approvals for private lands,
- Obtaining government approvals for public lands,
- Information required to plan your operation,
- Designing your operation,
- Preparing your pit or quarry,
- Operating your pit or quarry, and
- Closing your pit or quarry.

Information on selecting a land use for reclamation of your pit is provided in Chapter 3.

MINIMUM RECLAMATION REQUIREMENTS

Operators of pits and quarries in the Province of Alberta must meet certain minimum requirements for reclamation stipulated by the Land Conservation and Reclamation Council. Information on reclamation requirements and the approval process for ***private land*** is provided in the Sand and Gravel Manual by Alberta Environment. Information for ***public land*** (Crown-owned land) can be obtained from Alberta Forestry, Lands and Wildlife.

Large pit developments on private land are also required to obtain Development and Reclamation Approval (Development and Reclamation). A large pit development is any plant or operation for extraction and processing of sand, gravel, clay or marl, including associated storage and plant facilities and access/haul roads, that in total will disturb 2 ha (5 acres) or more of land. Development and Reclamation Approval is an agreement between the owner of a property or lessee and the Chairman of the Land Conservation and Reclamation Council that stipulates conditions related to pit reclamation, and protection of the surrounding land and environment.

For a small pit development on private land — an operation that will not disturb an area greater than 2 ha in size — no Development and Reclamation Approval is necessary. However, preparation of a "Development and Reclamation" type of plan for small operations can be useful in maximizing the extraction of the granular resource, with minimal cost and manpower requirements.

The new Alberta Environmental Protection and Enhancement Act is scheduled to come into force in 1992. Check with Alberta Environment (private lands) or Alberta Forestry, Lands and Wildlife (public lands) to ensure you are aware of the most recent requirements.

OBTAINING GOVERNMENT APPROVAL FOR PRIVATE LANDS

The Need For Development and Reclamation Approval

As discussed above, you may need to obtain Development and Reclamation Approval before you begin to develop your pit. Applying for Development and Reclamation Approval is straightforward. It involves submitting a written application, with supporting documentation, to Alberta Environment.

In the application, you are asked to describe and illustrate by means of plans and cross sections:

- existing surface and subsurface site conditions,
- the development sequence and proposed mining operation, and
- the methods that will be used to restore the area to an acceptable post-development land use.

To assist resource owners and lessees in completing and submitting applications for Development and Reclamation Approval, Alberta Environment has prepared "The Sand and Gravel Manual." This document may be obtained, free of charge, from the Land Reclamation Division of Alberta Environment (see Chapter 10).

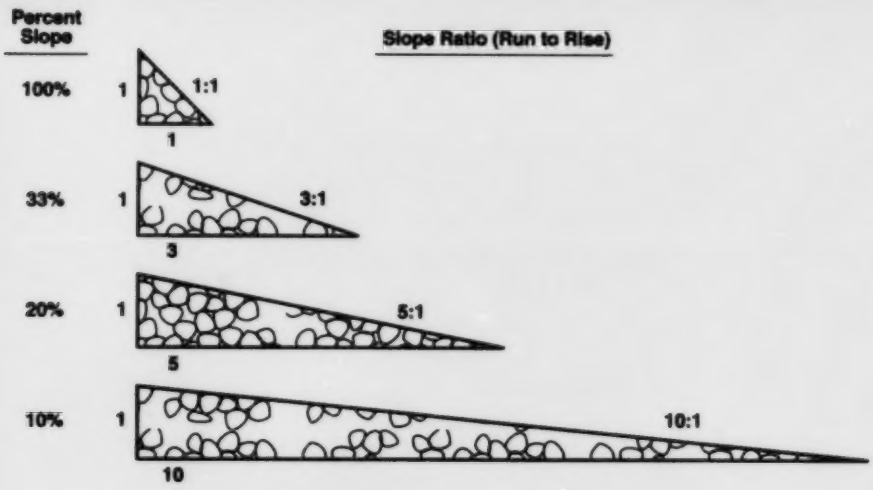


ILLUSTRATION 4, SLOPES ARE EXPRESSED AS THE RATIO OF THE HORIZONTAL RUN TO THE VERTICAL RISE

Minimum Reclamation Requirements on Private Land

Minimum reclamation requirements for pit and quarry operations on private lands are:

- Topsoil and overburden must be salvaged separately, properly stockpiled in a safe and accessible location, and replaced in proper sequence over the recontoured pit area. Topsoil must also be salvaged from all overburden and aggregate storage stockpile sites prior to use.
- An undisturbed buffer zone is required to protect adjacent land and permanent structures against adverse effects of the extraction operation. Buffers may also be required for wildlife movement corridors, aesthetics, noise control and erosion control.
- Depending on the specific site requirements, the size of the buffer may vary. Normal buffer zones for property lines, boundaries and road allowances are 3 metres (10 feet), or a distance equal to the total depth of the pit, whichever is greatest. For watercourses and waterbodies, a 30 metre (100 feet) or 60 metre (200 feet) buffer is required, depending on the stability of the bank or shoreline.
- Erosion of topsoil and overburden stockpiles must be controlled. Surface drainage must not enter adjacent land.
- Pit slopes must be reclaimed to a maximum 4:1 slope along the pit perimeter. A 4:1 slope means that the horizontal distance of the slope is four times the depth of the reclaimed pit (Illustration 4).

Additional reclamation guidelines may be applicable if the pit operation is on better quality agricultural land, along valley breaks, or near major water courses, or if the pit operation will mine below the water table. Other special requirements may be added, such as the need to protect wildlife habitat.

Obtaining Assistance for Private Lands

If you have questions about the Development and Reclamation application process for private land, or need help in completing the forms and drawings, the Development and Reclamation Review Branch of Alberta Environment will be pleased to assist. (see Chapter 10).

OBTAINING GOVERNMENT APPROVAL FOR PUBLIC LANDS

The Need For Development and Reclamation Authority

If you plan to develop a pit or quarry for surface materials on public lands (e.g., community pasture, Crown lands), you must first apply for surface rights and for access through Alberta Forestry, Lands and Wildlife, Public Lands Division. The application will determine if the proposed site is available for an extraction operation.

If approval is issued, the extent of the deposit must be determined within the area under application. This information is then used to determine the extent of the extraction, and the requirements for reclamation.

If you are applying for quarry development, you must possess the appropriate minerals lease issued by Alberta Energy. With your application, you will be required to submit and obtain approval on a development and reclamation plan, based on guidelines described in the publication "Development Impact and Reclamation Plan for Non-Regulated Mineral Extraction Projects on Public Lands". Copies of this publication are available from Alberta Forestry, Lands and Wildlife (see Chapter 10).

Minimum Reclamation Requirements for Public Lands

Reclamation on public lands must meet the minimum reclamation requirements (as described above), unless otherwise stated in the surface material lease agreement (SML) or the surface material license (SMC).

Obtaining Assistance for Public Lands

If you have questions about the application process for public lands, you should contact the Industrial and Commercial Land Section of Alberta Forestry, Lands and Wildlife (see Chapter 10).

INFORMATION REQUIRED TO PLAN YOUR OPERATION

The first step in planning your pit or quarry is to gather together and review information that may be available concerning existing site conditions and the occurrence of topsoil, overburden and extractable materials (Illustration 5). This information will provide you with a basis for preparing your application.

Surface materials and extractable materials are considered to be a nonrenewable resource. All efforts should be made to extract the materials in an effective manner to extract the maximum amount of material from the deposit and to minimize impacts on the environment.

For most pits and quarries, field investigations will be needed to obtain additional information on the distribution and abundance of extractable materials. You may want to retain a geotechnical expert to help you identify the specific location and quality of your deposit. Depending on the size and depth of your operation, field investigations may involve excavation of test pits and/or drilling of test holes, preferably on a grid pattern. Test pits can be

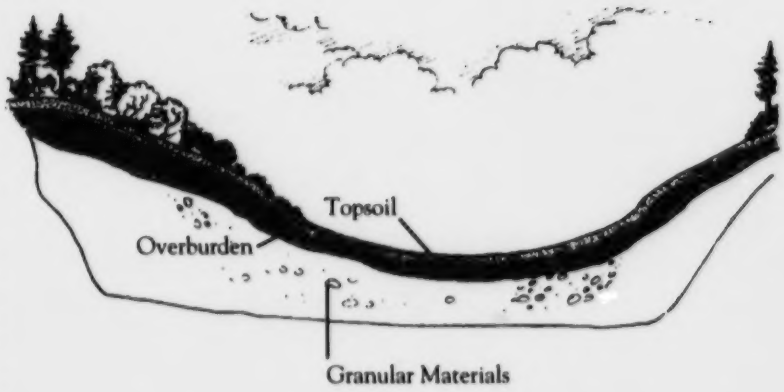


ILLUSTRATION 5, A CROSS-SECTION OF A GRAVEL DEPOSIT SHOWING THE TOPSOIL, OVERBURDEN AND GRANULAR MATERIAL LAYERS

dug by hand, or using a backhoe or bulldozer. Test holes may sometimes be completed with an auger, but usually require a drill rig. In all cases, the sequence of subsurface materials, the position of the groundwater table, and evidence of seepage should be noted. You may also want to retain samples for testing to determine material characteristics. For safety reasons, it is important to backfill all test excavations, and to leave the site in a clean, workmanlike manner.

Once you have obtained information on your deposit, you can develop an operational sequence that compliments progressive reclamation while maximizing extraction of the resource and minimizing environmental impacts. Operations that take reclamation into account as early as possible in the planning and development stage are generally the most cost efficient.

Topsoil

The distribution of organic-rich topsoil, in terms of its thickness and variations across your site, is important (Illustrations 5 & 6). In developing your pit, it is necessary to know how much topsoil material is available for salvage so that storage requirements can be estimated and possible stockpile locations can be identified. An estimate of topsoil volumes will also provide a basis for determining the average topsoil thickness to be replaced as reclamation proceeds.

Overburden

Mineral soil lying below the topsoil must often be removed to expose the surface materials for extraction (Illustrations 5 & 6). This material is known as overburden, and includes a broad range of materials, with different origins and compositions. Granular materials that are too coarse or fine-grained, and lenses or layers of non-granular materials such as silts, clays, peat and glacial till within a sand or gravel deposit, or overlying the sand and gravel, are also

generally treated as overburden.

Information on the distribution of overburden materials will likely be required during most stages of your development:

- during planning, to identify areas that are favourable for pit development (ideally, where overburden is shallow and granular materials are thick) as well as stockpile and storage areas (where overburden is thick, and granular aggregate is fairly thin or absent),
- during site preparation and layout, to estimate stripping volumes and determine storage and stockpile requirements, and
- at the reclamation stage, to establish overburden replacement requirements and, depending on the proposed end land use, to determine if additional fill materials needs will be needed.

Granular Materials for Extraction (Sand and Gravel)

The most important background information concerns the characteristics of the sand and gravel deposit. In some areas of Alberta, pits may be opened up to extract other materials, such as marl, bedrock and clay borrow. Similar considerations apply in all cases.

Deposit characteristics that will need to be considered for your operation include:

- the distribution of granular material. For example, are granular resources present throughout the property and, if not, in which specific areas are they present?
- the thickness and variability of the granular deposits;
- the composition of the granular material in terms of the gravel, sand and fines content and whether it is reasonably uniform or varies across the site or with depth;

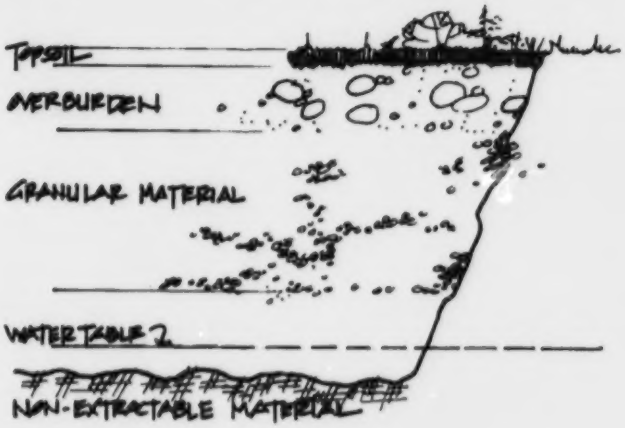


ILLUSTRATION 6,
DETAILED CROSS-SECTION
OF A GRAVEL DEPOSIT

- the quality of the granular resource, in terms of aggregate size and the presence of waste material;
- the distribution and thickness of overburden relative to the available granular resources; and
- the distribution of the granular resources relative to the local groundwater table.

Based on this information, volumes of different materials to be extracted can be estimated. The most suitable areas to locate the pit, topsoil and overburden stockpiles and other project facilities can now be identified.

Topographic Characteristics

In order to illustrate the potential impact of your operation on major landforms in the development area, you may want to compile topographic profiles. Cross sections can then be drafted for the development and reclamation plan, showing a comparison of what the area looks like before and after the proposed operation.

Groundwater Levels

The position of the groundwater table and its seasonal fluctuations have important implications for pit development. If the groundwater table is depressed, so that most or all of the deposit lies above it, then you can develop your pit "in the dry." In such cases, you can direct minor groundwater seepage flows into the pit and, if necessary, pump it out of a sump. This will help maintain a well-drained extraction operation.

When significant volumes of aggregate occur below the water table or its seasonally high level, there are three options to consider:

- The groundwater can be lowered by pumping, allowing a "dry" pit operation to be developed. You will need to obtain a permit for pumping from Alberta Environment;

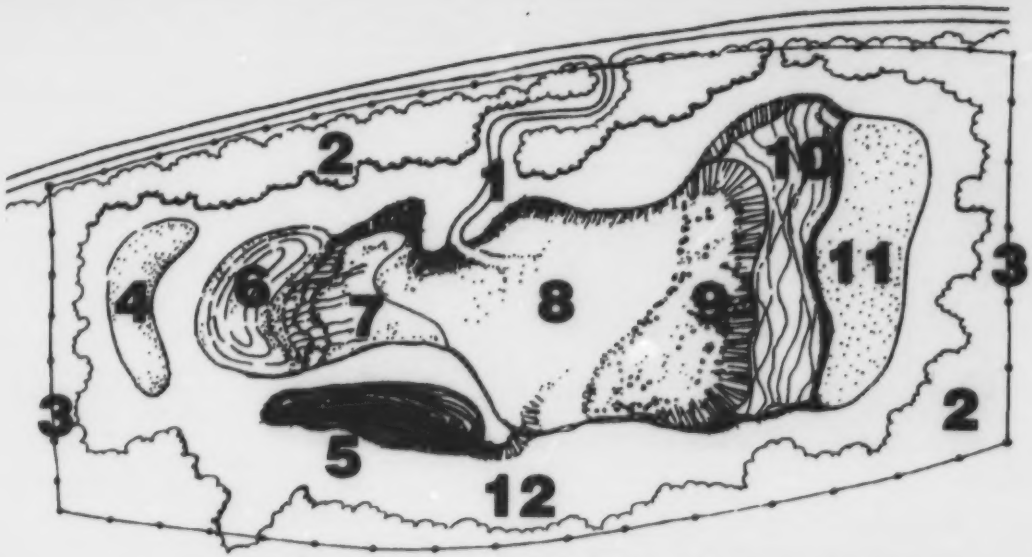
- When pumping is not feasible, the deposit may have to be developed "in the wet", using a drag line or similar equipment to extract the granular material; or
- You can halt operations when highwater conditions occur.

Disposal of produced water is often a concern with the first alternative, and sedimentation or settling ponds may be required.

High groundwater table conditions can also have an impact on your selection of a post-extraction end land use. As discussed in Chapters 4 to 9, high groundwater table conditions favour some land uses, notably wetland wildlife and fish habitat and some types of recreational developments,but are typically incompatible with land uses such as residential and industrial land development.

Flooding Potential

If you plan to develop deposits in or near rivers and creeks, flooding may be a concern. The requirement to establish undisturbed buffer zones close to watercourses will, to some extent, address this concern (see below). Nonetheless, you may need to construct dikes, or make provision for pumping. Before such preparations can be made, it is important to know whether a potential for flooding indeed exists. If so, how frequently will flooding occur and to what depth? Any activity within or adjacent to an active watercourse or the 1:100 year flood plain of a river requires a permit from Alberta Environment under the water Resources Act.



LEGEND

1) Dogleg access to screen view from road
2) Buffer Strip
3) Fencing
4) Topsoil Storage
5) Overburden Storage
6) Reclaimed
7) Progressive Active Reclamation
8) Working Space
9) Exposed Gravel
10) Overburden goes to active reclamation (7)
11) Topsoil goes to topsoil storage (4)
12) Cleared Area

ILLUSTRATION 7, PLAN VIEW OF A SAND AND GRAVEL OPERATION SHOWING THE ACTIVE PIT, TOPSOIL STORAGE, OVERBURDEN STORAGE, AGGREGATE STOCKPILES AND THE PROCESSING AND WASHING LOCATIONS

DESIGNING YOUR OPERATION

A typical extraction operation has a number of components or structures including:

- the pit itself,
- topsoil storage,
- overburden storage,
- product stockpile areas, and
- processing and/or washing plant locations (if required) (Illustration 7).

As discussed later in this chapter, it is important that you plan each of these components to compliment progressive development and reclamation.

Lease/License Conditions on Public Lands

Your approval to the surface rights may have attached conditions which will limit the scale of a pit or quarry on public lands. These conditions must be incorporated into the development and reclamation plan for your operation.

Location on the Property

The preferred pit location on the property will be determined by the characteristics of the deposit and by site conditions.

PHOTO 7, REGULATIONS REQUIRE THAT A BUFFER ZONE OF NATIVE VEGETATION IS MAINTAINED ALONG THE PROPERTY BOUNDARY AND ROAD ALLOWANCES

When a deposit is relatively uniform across the property, with respect to thickness, materials composition and quality, and when overburden (thin) and groundwater (depressed) conditions are similar, the pit can be located at the most favourable site in terms of the site development and access. This will permit materials extraction to be maximized and development to proceed in an orderly sequence and progressive fashion.

If the deposit, overburden and groundwater conditions are variable, it may only be feasible to extract material from the most favourable sections of the site. In this case, the pit might best be developed where the aggregate thickness and quality is greatest and/or the overburden is thin and groundwater is depressed.

Size, Shape and Depth

Market demands, environmental constraints, and the dimensions of the surface material deposit will largely determine the size, shape and depth of your pit or quarry. Overburden distribution and groundwater conditions will also influence the final configuration. It should also be possible to take into account the proposed end land use. With a specific use in mind, it is feasible, for example:

- to develop irregular rather than regular pit walls, so as to improve site conditions for recreational or wildlife uses,
- to excavate material from below the water table, so that water-related uses can be developed, or
- to raise site grades following extraction (by importing fill material) to favour industrial and residential uses .

Chapters 4 to 9 address such considerations for a variety of possible end land uses.

PHOTO 8, STOCKPILES WILL BE REQUIRED FOR THE LONG-TERM STORAGE OF TOPSOIL AND OVERBURDEN

Buffer Zones

Undisturbed buffer zones must be incorporated into the development plan along the property boundaries and road allowances and adjacent to permanent natural and man-made structures (Photo 7). The primary intention is to protect pre-existing site features from adverse impacts (such as slumping) due to the operation. In addition, slope grading can be carried out at pit abandonment without impacts on natural features and man-made structures.

Storage and Stockpile Sites

Before site clearing and extraction begins, you will need to identify sites for long-term storage of the topsoil and overburden that are stripped from your initial extraction area (Photo 8). These materials must be stored separately, so that mixing of topsoil and overburden does not occur. You may also want to set aside areas for stockpiling of pit-run and/or processed aggregate during the normal course of the extraction operation.

Approximate areas required for long-term topsoil and overburden storage can be determined based on the estimates of initial stripping volumes. If possible, you should locate storage sites in areas that will not be disturbed by the mining operation, so that "double handling" of materials is avoided. Stockpiles should not be located in areas where water will accumulate.

Stockpiling of aggregate is typically temporary, and may take place in areas that are mined out but not yet reclaimed, or in areas that have not yet been mined. In either event, you will want to locate the stockpiles where they will not impede the extraction operation or hinder the orderly progressive reclamation of your site. Easy access to stockpiles, and the location of weigh scales (if required) are other important considerations in locating material stockpiles.

Site Drainage

It is important that surface runoff from your operation does not flow onto adjacent properties. Good drainage of the pit area should be encouraged as it will also contribute to an efficient mining operation.

Good surface drainage can be achieved by directing runoff and any groundwater seepage to the low point of the pit. If necessary, drainage ditches may need to be constructed, draining to a sump. Water can then be pumped from the sump for disposal. Note, however, that you must obtain a license from Alberta Environment to discharge any water into adjacent water courses or waterbodies. Disposal of water should be addressed in your operation plan.

A settling pond will be required before discharge to any surface water course is permitted. If a wash plant is operated, waste water will need to be recycled rather than disposed of. Ditching or pumping of excess water onto public lands must have prior approval of the Public Lands Division.

Effective pit drainage is especially important where material is to be extracted from below the groundwater table. As described above, pumping from a sump will generally be required to maintain a "dry" operation. As an alternative, you could use a drag line or clamshell to extract the product.

Working with Your Local Reclamation Officer

As well as assisting with the application for Development and Reclamation authority, your local Public Lands Reclamation Officer can provide advice during development, from initial site preparation, through pit development and operation, to final site clean-up and reclamation. In particular, he or she will help you implement progressive reclamation procedures, in which the site is reclaimed in sequence with the extraction of granular material, rather than at the end of the operation (termed "terminal" reclamation).

PREPARING YOUR PIT OR QUARRY

Once Development and Reclamation authority and surface lease approval (on public lands) is received, site preparation can commence. This should be carried out in accordance with the plan submitted with your approved application. In particular, clearing and stripping should be confined at first to the initial extraction area and stockpile sites identified in the sequential development and reclamation plan. At each stage of the development, only the minimum area necessary for pit operations should be cleared.

Layout

The first task is to layout the various project components on the ground, including:

- the property boundaries,
- undisturbed buffer zones,
- the initial pit area,
- topsoil storage area,
- overburden storage area,
- processing facilities such as the crusher, washing plant, and weigh scales (if part of the operation),
- product stockpile site(s), and
- surface drainage facilities (ditches, sump, etc.).

Facility layout prior to, rather than during, mining will promote an orderly and efficient operation. Double handling of topsoil and overburden can also be avoided or at least minimized. Development and reclamation of the site can then proceed in a progressive fashion, as described in your plan.

PHOTO 9, NON-MERCHANTABLE TIMBER AND BRUSH CAN BE BURNED, BUT YOU MAY NEED TO OBTAIN A PERMIT (SEE TEXT)

Clearing and Grubbing

Brush and trees, if present, should then be removed from the initial pit area, storage and stockpile sites, access roads and any proposed processing facility locations. Merchantable timber, if present, should be salvaged. On public lands, timber salvage requirements will normally be specified in your license/lease agreement. If you are unsure, check with the Public Lands Division of Alberta Forestry, Lands and Wildlife.

Depending on your final land use, roots and stumps may need to be grubbed once clearing and timber salvage is completed. If this material is not a hazard, it can be left in place to conserve topsoil. If stumps and roots are removed, they can be stockpiled for use as erosion control on slopes or to create cover for small wildlife. Brush and tree waste can also be chipped for use as a landscape mulch, or combined with a high nitrogen fertilizer for reclamation of the site.

Excess stumps and roots can be burned (Photo 9). On private land, you should check with your local municipal government or the Land Reclamation Division of Alberta Environment to determine if a burning permit is required for your operation. On public lands, you must contact the Alberta Forest Service to obtain a burning permit.

Topsoil Stripping and Stockpiling

After clearing and grubbing, you should strip and stockpile organic-rich topsoil from:

- the area to be opened for the pit or quarry;
- an area around the pit or quarry excavation that is at least as wide as the maximum depth of the pit walls to allow for slumping and to provide access; and
- the overburden storage and product stockpile areas.

There is no need to remove the existing topsoil from the topsoil storage site.

PHOTO 10, ONCE TOPSOIL HAS BEEN SALVAGED FROM YOUR PIT AREA, THE OVERBURDEN CAN BE REMOVED

You should stockpile topsoil from the initial phase of site clearing in the storage area identified on the pit design plan. Topsoil should be stored separately from the overburden, and not contain any large roots or stumps. To minimize erosion and cut down on weed growth, you will want to seed the stockpile with grasses such as oats or rye, or a legume such as clover or alfalfa. Keep in mind that thin topsoil salvage piles (e.g., 1 to 2 m in depth) tend to maintain topsoil quality better than thick piles. Regardless of the pile depth, piling and spreading activities should be minimized to limit topsoil loss.

The initial topsoil stockpile will typically remain undisturbed until the final stage of site reclamation. In the interim, topsoil material stripped from other areas is used progressively for reclamation, so that "double handling" of materials is minimized.

Overburden Stripping and Stockpiling

When topsoil salvage is completed, you can begin stripping overburden from the initial pit area (Photo 10). Overburden material should be stockpiled separately from the topsoil in the area designated in the plan. As with the topsoil, erosion potential can be minimized by seeding the overburden stockpile with grasses and/or legumes; this will also reduce weed growth. Again, overburden materials stripped during initial site preparation will be stockpiled until the final site reclamation stage. As part of the progressive and sequential development and reclamation plan, overburden salvaged from new areas is used to reclaim the previous extraction area.

Timing

While it may be feasible or even desirable, to clear the development site during the winter, grubbing of roots and stumps while the ground is frozen is very difficult. It is also next to impossible to salvage topsoil separately from the underlying overburden when the near-surface soils are frozen. Therefore, grubbing (where needed), topsoil salvage and overburden removal should be carried out when the ground is not frozen.

OPERATING YOUR PIT OR QUARRY

When site preparations are complete, you are ready to begin extracting granular or quarriable material. This should be carried out sequentially so that progressive operation and reclamation of the site is achieved.

Progressive Reclamation and Development

For very small sand and gravel deposits, it is sometimes possible to complete the site preparation - extraction - site restoration sequence within the space of one year. Most granular and quarriable material sites are larger, however, and cannot be developed within such a short period of time. The recommended approach in such cases is for the operator to subdivide the deposit into more or less equal segments (in terms of stripping requirements and extraction volume). These areas should be of such a size that site preparation, materials extraction and reclamation can be completed within one year.

The above procedures ensure that the operator has an efficient and orderly pit to work, and that reclamation proceeds in a progressive and ongoing fashion. Terminal reclamation, in which site reclamation activities are left until all material has been extracted, should be avoided.

Materials Handling

To keep your operation efficient, you should minimize or avoid "double handling" of topsoil, overburden and granular aggregate materials. You can best do this by progressively developing and reclaiming your pit or quarry. With the exception of the materials that are salvaged from the initial extraction area, topsoil and overburden can be directly moved from each new pit area to the adjacent reclamation site. As noted, topsoil and overburden

PHOTO 11, ALL SURFACE WATER DRAINAGE IN YOUR PIT SHOULD BE DIRECTED TO A SUMP

from your initial pit should be stockpiled for the duration of your operation, and then be used in reclaiming the last operating area on your property. You can also reduce materials handling by extracting and processing materials only as they are required and sold.

Equipment

The type of equipment that you use will depend on the size of your proposed operation, your need for processing, and the local availability of equipment.

Stripping, stockpiling and replacement of topsoil and overburden is generally carried out using scrapers (buggies), bulldozers or graders. Extraction of the exposed granular material is typically carried out using a loader and truck operation. If material from below the water table is to be mined, drag lines and clamshells may be used.

Pit Dewatering

Requirements for dewatering will usually be minimal when extraction operations take place above the seasonally high groundwater table. In such "dry" pits, it is necessary only to maintain positive site drainage, by directing surface runoff, and groundwater seepage where encountered to the low point of the extraction area. From this point, it may be disposed of by pumping, if it presents a hindrance to the operation, or left where it is. Drainage from the area around the pit should be directed away, where possible.

When granular material is to be extracted from below the groundwater table, pit dewatering can be more difficult. Two options are available, depending upon whether or not it is feasible to draw down the water level:

- pumps may be installed around the perimeter with a series of in-pit ditches, draining to a sump constructed at the low point of the pit (Photo 11), or

PHOTO 12, GRAVEL MAY BE "WET" EXTRACTED USING A CLAMSHELL OR DRAG LINE

- a "wet" extraction operation may be developed (when it is not practical to lower the water level), in which a drag line, clam shell or similar equipment is used to extract the aggregate (Photo 12).

Where significant volumes of water have to be disposed of, siltation ponds will need to be established so that good quality water is released to the environment. When a wash plant is used, waste water must be recycled through the process.

CLOSING YOUR PIT OR QUARRY

When the last aggregate extraction area is depleted, the final phase in the operations plan is to abandon the pit or quarry and complete reclamation of the site. As with the site preparation and operation phases, closing should be carried out as part of a progressive reclamation plan.

Temporary and Permanent Abandonment

A pit may be abandoned on either a temporary or permanent basis.

Temporary abandonment occurs most frequently when a short-term lack of demand develops before the resources of the pit or quarry are exhausted. In this case, the operator need only clean-up the pit or quarry area and address drainage and erosion concerns. For safety, you may want to fence and sign the pit or quarry. When demand for aggregate is re-established, operation of the pit or quarry can continue.

Permanent abandonment must be considered when the resources of the pit or quarry are depleted. In addition to clean-up and implementation of drainage and erosion measures, site grading, topsoil and overburden

replacement and site revegetation will need to be undertaken. Abandonment operations must be carried out bearing in mind the end land use for your site. Site-specific recommendations for different land uses are described in Chapters 4 to 9.

Once you have completed permanent reclamation of your pit or quarry, you will need to obtain a Reclamation Certificate from the Land Conservation and Reclamation Council: contact the local Alberta Environment officer (for private lands) or the local Public Lands or Alberta Forest Service officer (for public lands).

Site Clean-up

A clean pit area should be maintained for the duration of the extraction operation. Prior to abandonment, all remaining debris and garbage must be removed from the site. If abandonment is permanent, equipment and buildings must also be removed. In very stony pits, disposal of large boulders may not be a concern unless a residential or industrial use is planned, and the boulders are likely to create a problem for deep foundations. In most cases, boulders can be buried in the abandoned pit, beneath a layer of backfill or overburden material. However, as large boulders can be sold for landscaping purposes in urban areas or recreational sites, you may want to try to sell these materials. At minimum, you should note or mark the location of the boulder disposal site for future use.

Weed control is an important consideration in site maintenance and abandonment, particularly in relation to topsoil and overburden stockpiles. Weed growth can often become a problem and will need to be controlled. For advice on weed control, contact your local municipality or District Agrologist (for private lands) or Alberta Public Lands Division (for public lands).

PHOTO 13, ONCE YOU HAVE RESHAPED THE BACKFILL TO ITS FINAL CONTOURS, TOPSOIL SHOULD BE REPLACED IN AN EVEN LIFT

Slopes and Grades

Pit slopes should be graded back and recontoured to blend in with the adjacent natural contours. Objectives are two-fold: to minimize potential for erosion and to prepare the site for the proposed post-extraction land use.

When the site is to be abandoned temporarily, it is satisfactory to "round" the slope crests, and to grade the pit slopes to a gradient not steeper than 2:1. This will minimize erosion in the pit area.

For permanent abandonment, long-term slopes cannot be steeper than 4:1(see Minimum Reclamation Requirements above) (Illustration 4). In practice, much gentler final slopes are required for most land uses (see Chapters 4 to 9).

Backfilling and Overburden Replacement

Once "rough grading" of the pit areas has been completed, replacement of overburden can begin. In most instances, available material should be spread evenly across the disturbed site (Photo 13). For some land uses, however, this may not be required. When development of ponds and lakes is proposed, for example, it is unnecessary to replace overburden material in areas that will be below the water level. For other uses, notably development for residential and industrial lots, additional fill material may be needed, so that satisfactory final grades can be established by backfilling. Specific requirements for various land uses are detailed in Chapters 4 to 9.

Drainage and Erosion Control

When a pit is abandoned on a temporary basis, drainage and erosion control measures should aim to promote positive site drainage and ensure that access to remaining reserves is maintained. Once the deposit is depleted and is to be permanently abandoned, final slope grading will, in most instances, minimize erosion potential. Unless development of waterbodies is considered, positive drainage off the site should be maintained for most potential land uses.

Topsoil Replacement

Finally, topsoil that was stripped from the initial pit area (and since stockpiled) should be spread evenly across the final extraction area (Photo 13). As with the overburden, it may not be necessary in all cases to replace topsoil on all reclaimed areas. If waterbodies are to be created, you should only replace topsoil along the upper shoreline of a wetland (up to 1.5 metres below the highwater mark) where aquatic plants will require soil for rooting. No topsoil need be applied in the deeper portions of the basin where these plants are not able to grow.

THE NEXT STEP

In the next chapter, potential land uses for reclaimed areas in Alberta are described. Factors that you should consider in selecting the best land use for the property are also described.

If you are familiar with these options, and have already selected a land use for your site, Chapters 4 through 9 provide specific details on reclamation for agriculture, forestry, wildlife habitat, fish habitat, recreation, and residential and industrial uses, respectively.

SELECTING A PREFERRED LAND USE FOR RECLAMATION

Now that you are familiar with the important general steps in designing and operating a pit or quarry operation from start to finish, Chapter 3 describes how you can select the most appropriate land use or uses for your operation. Information on specific land uses and reclamation methods is provided in Chapter 4 through Chapter 9.

In this chapter, information is provided on:

- Potential land uses:
  - agriculture,
  - forestry,
  - wildlife habitat.
  - fish habitat,
  - recreation, and
  - residential and industrial use.
- Important considerations in selecting a land use for reclamation:
  - regional limitations,
  - environmental limitations,
  - size and depth of the pit or quarry,
  - surrounding land uses,
  - land use zoning, and
  - costs.

POTENTIAL LAND USES

Within Alberta, there are six major land uses that can be considered for pit and quarry operations. On private land, the choice of an end land use is generally up to you. On public lands, the end land use will likely be determined by the agency that administers the land.

In general, pits and quarries in good quality agricultural land are reclaimed for agricultural purposes, whereas extraction sites in productive forest are reclaimed for forestry. A decision to reclaim a pit or quarry for other land uses such as wildlife habitat, fish habitat, recreation, residential use or industrial use should be made well in advance of project start-up as different approvals will likely be required by Alberta Environment or Alberta Forestry, Lands and Wildlife.

Agriculture

Depending on your location in the province, agriculture can include production of cereal crops, forage crops and livestock. Reclamation must focus on restoring gentle landforms, establishing good drainage and reconstructing an acceptable soil. If your operation is to be located in an area of high quality farmland, an agricultural end use will likely be required.

Forestry

A forestry land use assumes that trees will be established and grown primarily for timber, either on a commercial or local woodlot scale. Reclamation for forestry normally must provide moderate to gently rolling landforms, and good drainage. It is best considered when your operation is located within a forestry area, or near existing tree farms.

Wildlife Habitat

A wildlife habitat land use assumes that combinations of landforms, waterbodies and/or water courses, and vegetation will be established to provide the basic needs of wildlife for food, water, cover and space. As a mixture of landforms, waterforms, and vegetation can provide habitat for a variety of wildlife, this land use is adaptable to many operations throughout the province.

Fish Habitat

As fish habitat must include a year-round source of high quality, deep water, it is a specialized use that is suitable only for operations in which permanent waterbodies or water courses will be formed through drainage from adjacent areas, or by excavating into the groundwater table. Adequate food supplies must also be provided.

Recreation

Recreation includes a wide variety of uses ranging from casual, nature-oriented activities such as hiking and bird watching to formalized activities such as field sports, tennis or dirt-bike racing. Due to the large number of possible activities, a recreation land use is adaptable to a large number of extraction operations. However, to be successful, recreational projects must meet regional demands for the types of facilities being offered, have good access, and be in proximity to an adequate user population. Public safety is also of high importance.

Residential and Industrial Use

Residential use can range from a country acreage or home, to a high-density housing development in cities and towns. Visual quality of the site is important, as are safety considerations such as slope slumping or ground shifting. Residential development will usually require the construction of a more costly infrastructure such as water and sewer lines, electrical supply, and road access.

Industrial uses can include a wide range of activities such as buildings, storage sites and processing. As with residential uses, safety considerations are very important, and may limit the use and value of the site. Infrastructure costs can also be high. Use of pits and quarries as waste disposal sites is generally not permitted, as wastes can contaminate groundwater sources, surface water and soil.

IMPORTANT CONSIDERATIONS IN SELECTING A LAND USE FOR RECLAMATION

You may have already thought about the way you want to reclaim your operation. Your choice is important as you will likely see and use the site on a regular basis. As the land owner, your choice may also affect the eventual resale value of your property.

If you haven't thought about an end use, you might want to list some of the things you value most about the proposed development area, or the uses that are in shortest supply. For example, if your pit is on Class I and II agricultural land, you will likely have to reclaim the area for agricultural use. In contrast, land on the fringe of a major urban centre may most appropriately be developed for residential or industrial use. If you enjoy the outdoors and want your own "wild" oasis, habitat for fish and wildlife may be your preferred choice. You might even combine a recreational use with a fish and wildlife use.

As long as your preference is a realistic goal for the specific conditions on your property, the choice is up to you.

On public lands, government agencies will usually stipulate the preferred land use.

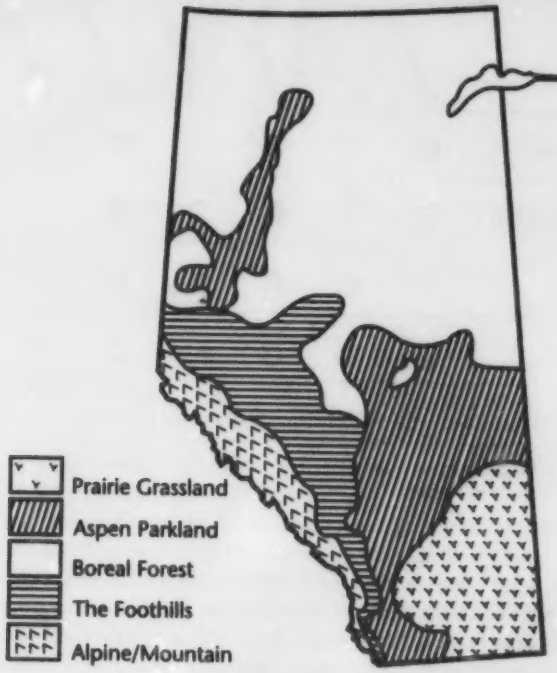


ILLUSTRATION 8, THE ECOREGIONS OF ALBERTA

Regional Limitations

Natural factors on and adjacent to your operation will strongly determine the types of land uses that are attainable. Regional factors such as climate, soil types, and landforms will strongly influence the types of plant cover that can be grown, and the types of waterbodies that might be developed. The combination of these physical factors and biological factors will set limits to the types of land uses that can be developed on your property (Illustration 8).

Alberta can be divided into five broad regions based on climate, soil types, landforms and vegetation cover:

- the prairie grassland,
- the aspen parkland,
- the boreal forest, and
- the foothills.

A fifth region, the alpine/ mountain region, also occurs but is outside the scope of this handbook.

	Agriculture	Forestry	Wildlife	Fish Habitat	Recreational	Residential	Industrial
Grasslands	✓	✓	✓	✓	✓	✓	✓
Aspen Parkland	✓	✓	✓	✓	✓	✓	✓
Boreal Forest	✓	✓	✓	✓	✓	✓	✓
The Foothills	✓	✓	✓	✓	✓	✓	✓

✓ Preferred Land Uses ✓ Suitable Land Uses in Selected Areas

CHART 1, SUITABLE LAND USES FOR EACH OF THE FOUR REGIONS

The Prairie Grassland Region

The prairie grassland region is characterized by gently rolling to flat terrain, and gently to deeply cut coulees near major drainages. The region has cold winters, warm summers and generally receives little rain. It is the driest region of the province during both winter and summer. High summer temperatures, strong winds, low precipitation and long periods of sun result in rapid losses of water from vegetation and soil. In parts of this region, rapid changes in winter temperatures and loss of snow cover during chinooks create very difficult growing conditions for plants, particularly trees and shrubs. As a result, grasslands are the predominant native habitat type, Shrub and tree communities are generally restricted to moist areas along northerly and east-facing slopes, coulee bottoms and river floodplains. Dominant land uses in the grassland area are cattle production, cereal crop production, and on irrigated land, forage and vegetable production. Due to the extremes of climate in this region, wildlife are generally restricted to coulees, watercourses and other depressions.

The Aspen Parkland Region

The aspen parkland region occupies much of the south central region of the province. Rolling knob and kettle landforms are common. The region is characterized by cold winters, warm summers and heavier precipitation in July and August than more southerly areas of Alberta. Increased summer rain reduces the drying out of plants and soil, and is critical to the survival of trees and shrubs. Lower winter temperatures and decreased numbers of chinooks prolong snow cover and increase snow depth. These favourable moisture conditions support a lush and diverse mixture of trees, shrubs, herbs and grasses dominated by trembling aspen, saskatoon, wild rose, silverberry, and snowberry. With some of the best quality soil in the province, the aspen region is one of the most productive farming areas. Wheat, canola, and oats are common crops. Due to the large numbers of wetlands and the mixture of

open and forested areas, the aspen parkland is also an extremely important area for wildlife, particularly waterfowl.

The Boreal Region

The boreal region occupies most of the northern half of the province. With few exceptions, the area is flat to gently rolling. Summers are cool and moist. Winters can be extremely cold, being dominated by the very cold, dry, Arctic air mass. Snow cover is usually deep and uniform relative to other areas of the province. Native vegetation consists either of mixedwood forests, coniferous or evergreen forests, and bogs. Common trees include trembling aspen, balsam poplar, white spruce, black spruce, and jack pine. Shrub understories are normally made up of saskatoon, dogwood and/or willows. Farming is common along the southern edge of the region, as well as throughout the Peace River region. Forestry is an increasingly important land use, particularly in relation to hardwood harvesting for pulp and paper. Due to the large area of forested habitats, the boreal region supports some of the highest number of moose, other large game and furbearers in the province.

The Foothills Region

The foothills region runs in a band along the western edge of the province, parallel to the Rocky Mountains. Dominant landforms include hilly to near-mountainous terrain. Summers are cool and moist, with the greatest rainfall normally in July. Winters are cold, commonly with high snow depths. Trembling aspen, balsam poplar, lodgepole pine and white spruce are the most common trees. Grasslands are normally only found on dry, south-facing slopes. As the foothills region is the most productive forest in Alberta, logging is one of the most important industries. Cattle ranching and limited crop production occur along the eastern edge of this region. As in the boreal forest, the large areas of forested habitat support a diversity of wildlife. Some wildlife with more specialized habitat requirements such as bighorn sheep are also present.

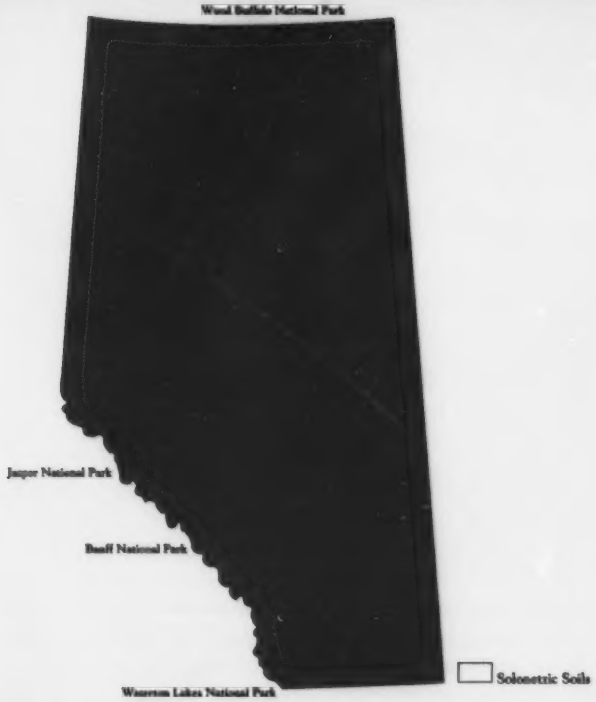


ILLUSTRATION 9, THE MAJOR SOIL TYPES OF ALBERTA

Environmental Limitations

Environmental conditions within each of these regions will limit the types of land uses that can be selected for successful reclamation.

Climate will determine what kinds of vegetation and waterbodies can be established and maintained in your area. Dry conditions in the grassland region will limit uses dependent on the establishment of trees and shrubs, or the maintenance of permanent water. Snow depths and winter temperatures may also limit some recreational uses.

Soil types will also strongly influence the future use of a site for agriculture, forestry, wildlife habitat and recreation. Saline or alkali soils are more common in the southern and eastern areas of the province. In extreme cases, these soils can prevent growing of cereal and some forage crops, and establishment of trees and shrubs. Acidic soils, commonly associated with sandy soils, bogs and fens in northern Alberta can also restrict the types of plant communities that can be established (Illustration 9).

Types and quality of water, and the permanency of water will determine if fish habitat, some wildlife habitats such as wetlands, and water-based recreational uses are possible. Poor local drainage will also make farming, forestry, residential and industrial uses less desirable.

Landforms will also influence your decision. Moderately to steeply rolling land and steep slopes will prevent easy and safe use of farming machinery or mechanical tree harvesters. Steep or uneven terrain will limit construction of

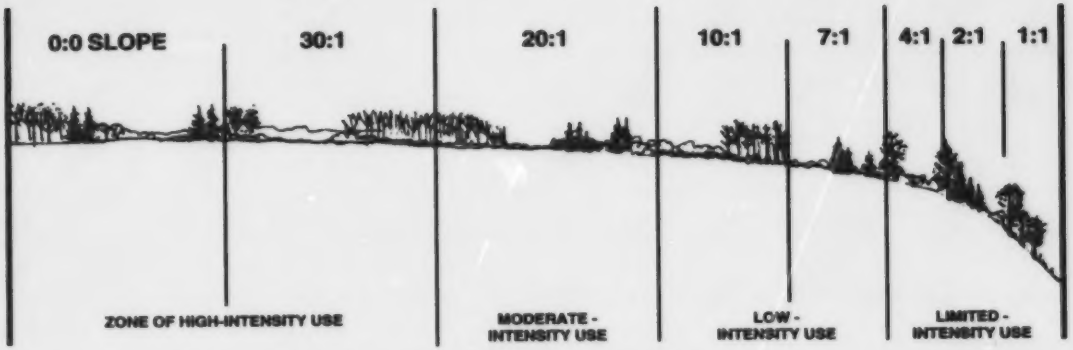


ILLUSTRATION 10. LANDFORMS, PARTICULARLY SLOPE, STRONGLY INFLUENCE THE LAND USE INTENSITY FOR RECLAIMED PITS (SEE CHAPTERS 4 TO 9 FOR SPECIFIC LAND USES AND SLOPES)

permanent buildings and other facilities. There is also higher potential for erosion on steep slopes. A site located on low-lying lands such as floodplains is most suitable for wildlife habitat, fish habitat and/or recreation. Flood risks would not permit residential, industrial or intensive recreational use. Unusual landforms and drainage channels are suitable for wildlife habitat, fish habitat and/or recreation. Suitable land use intensities for different landforms and slopes are shown in (Illustration 10).

Size and Depth of the Pit or Quarry

The final size and depth of your final pit or quarry will also influence your choice of a final land use.

In general, if a pit is less than 2 ha in size, it is best to return the land to a similar use as adjacent lands. However, small operations such as this do offer excellent opportunities for development of wildlife habitat, fish habitat or casual recreation. Larger reclamation areas provide increasing opportunity for re-establishment of any of the six land uses described above. In particular, forestry and agricultural uses require large land areas to make harvesting of trees and crops practical. Residential and industrial land uses also require large land areas to justify costs for site development For large operations, it is also increasingly feasible to combine two or more land uses within the reclaimed area.

The depth of your pit relative to the remaining land surface will also influence your choice of land use. Shallow pits less than 3 metres deep can provide suitable sites for almost any land use, with the exception of fish habitat. Moderately-deep pits with depths of 3 to 7 metres can provide opportunities for wildlife habitat, fish habitat and recreation. The greater depth and the need and costs for recontouring make other uses less suitable. Pits more than 7 metres in depth are likely to be suitable only for wildlife habitat or fish habitat, unless substantial recontouring is included as part of the pit development plan.

Surrounding Land Uses

It is important that the land use you select for your operation is compatible with land uses in directly adjacent properties (Chart2). A safe rule of thumb is to return the site to a use similar to what existed prior to disturbance, or uses common in surrounding areas. However, some site conditions encourage innovative designs that will add diversity to the landscape while still complementing adjacent land uses. For example, wildlife habitat, fish habitat and recreational uses can often be developed in areas dominated by grasslands or forests to provide a pleasing but different element in the landscape.

Location of your operation relative to city centres and towns is also important. In many cases, zoning regulations by the city, town or municipal district, or integrated resource planning will dictate the kinds of land uses that can be considered.

Sites within the fringes of towns and cities are often best developed for intensive uses such as residential developments, industry and organized recreational uses such as parks, golf courses, or sports complexes. On the periphery of urban centres, however, less intensive uses such as country residential, wildlife habitat, fish habitat and nature-oriented recreation are possibilities. Sites in developed rural areas might be better suited for farming, wildlife habitat and/or fish habitat.

Development of certain land uses next to other land uses must also recognize the potential for creating problems with public access and vandalism, noise, pollutants, and wildlife. For example, recreational areas require good access and regular maintenance. Depending on the type of recreational use, some supervision may be necessary to control problems such as vandalism. Creation of wildlife habitat in farming areas must consider the potential for disturbance or damage to crops. Creation of fish habitat near agricultural, residential or industrial areas must also consider the potential for contamination of water by fertilizers, effluents and air pollutants. Development of an industrial site next to a residential area or a natural area may result in problems with noise, dust and air emissions.

	Agriculture	Forestry	Wildlife	Fish Habitat	Recreational	Residential	Industrial
Agriculture	✓	⊗	✓	✓	✓	⊗	⊗
Forestry	⊗	✓	✓	✓	✓	⊗	⊗
Wildlife Habitat	✓	✓	✓	✓	✓	✓	⊗
Fish Habitit	✓	✓	✓	✓	✓	✓	⊗
Recreation	✓	✓	✓	✓	✓	✓	⊗
Residential	⊗	⊗	✓	✓	✓	✓	✓
Industrial	⊗	⊗	⊗	⊗	⊗	✓	✓

✓ Compatible ✓ Compatible in some cases ⊗ Least Compatible

CHART 2:
COMPATIBILITY OF LAND USES FOR PIT AND QUARRY OPERATIONS RELATIVE TO ADJACENT LAND USES

Land Use Zoning

Before planning and developing your site, be sure to review local ordinances and current and proposed Land Use Zoning regulations. These regulations, established by the Regional Planning District offices and the Provincial Government, will allow you to determine what kinds of developments or land uses will be permitted on your site, and the types of restrictions that may apply for each type of permitted land use.

Costs

For private operations, you are one of the best judges of what the reclaimed land from your operation will be worth. On public lands, government agencies generally select the final land use.

Within a city's or town's limits, land values may justify the expenditures for regrading of a pit and quarry, site drainage, and installation of sewer, water and electrical systems for residential and industrial development. In contrast, need for open spaces and recreational facilities may also make recreational uses and wildlife habitat a viable land use.

In areas with good farming capability, land values may similarly justify the cost of regrading and careful replacement of soil to return the land to an agricultural use. However, if soil problems are present, a wildlife habitat or recreational use may be more appropriate. In recent years, many rural land owners have developed "islands" of wildlife habitat or fish habitat on their

land. Pits and quarries are often ideal locations for these uses.

In remote areas, forestry and wildlife habitat are often the only cost-effective uses. Within the forested area of the province, you may be required to restore your operation to a productive forestry use.

WHERE TO GO FROM HERE

If you have now decided on one or more land uses for your operation, Chapters 4 through 9 can provide you with detailed information on important considerations during design and operation, as well as information on reclamation techniques, equipment use, soil handling and revegetation.

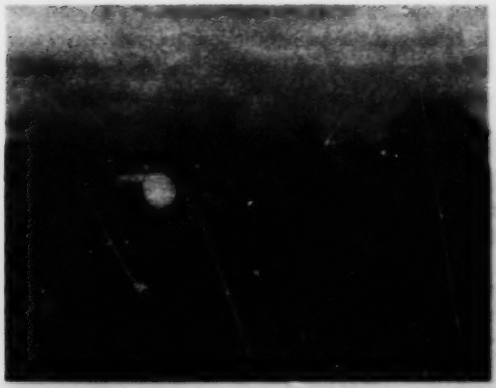
If You Selected:	Turn To:
Agriculture	Chapter 4
Forestry	Chapter 5
Wildlife Habitat	Chapter 6
Fish Habitat	Chapter 7
Recreation	Chapter 8
Residential or Industrial	Chapter 9

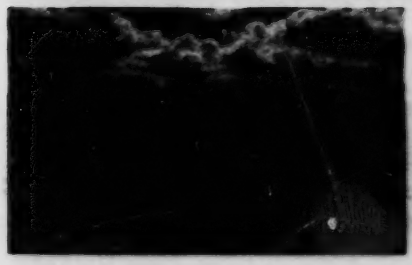
If you are still unsure of the best land use for your operation, a number of government agencies can assist you in your selection. Possible contacts in Alberta Environment, Alberta Forestry, Lands and Wildlife, Alberta Recreation and Parks, Alberta Agriculture, and Alberta Municipal Affairs are listed in Chapter 10.

RECLAIMING LAND FOR AGRICULTURE

If you have selected agriculture as the end land use for your pit or quarry, this chapter provides specific information on issues that may affect agricultural land uses on your property, including:

- Important considerations in reclaiming your site for agriculture:
  - adjacent land uses and zoning,
  - soil types and availability,
  - soil salvaging,
  - progressive reclamation and development, and
  - shape, size and depth of your pit or quarry.
- Methods for reclamation:
  - grading and contouring,
  - replacing overburden,
  - site drainage,
  - replacing topsoil, and
  - planting cover crops.





IMPORTANT CONSIDERATIONS IN RECLAIMING YOUR SITE FOR AGRICULTURE

In areas with a good to high capability for farming, it is important that you carefully plan your reclamation program so that the land is successfully returned to a capability equivalent to that existing prior to disturbance. There may even be potential for you to improve land that was unsuitable for farming due to adverse or irregular landforms.

A number of factors will determine the success of your reclamation program for agriculture, and the types of agricultural uses that are best suited to your particular site conditions.

Adjacent Land Uses and Zoning

Adjacent land uses often affect or limit options when planning surface drainage, and slope lengths and grades, and therefore limit land capability for agricultural use. For example,

- reclamation to pastureland may be most appropriate when the pit is located within a large pastureland area. It would not be appropriate, however, in a cereal crop area where cattle grazing is uncommon.
- pits that are located in depressional areas and collect water from surrounding areas may be too wet for cereal crops and some forage.

Before planning and developing your site for agriculture, be sure to review local ordinances and current and proposed Land Use Zoning regulations. These regulations, established by the Regional Planning District offices and the Provincial Government, will allow you to determine if agricultural uses will be permitted on your site.

Soil Types and Availability

The soil types and topography within your proposed pit area determine your land's capability for agriculture, and therefore set your goal for reclamation. As soil type and quality will strongly influence the types of agricultural uses that can be developed on your reclamation area, it is important that you obtain information on soil types, location, and depth prior to disturbance.

Soil types are related closely to landforms and geological materials, and mapping of soil types can often be based on landforms and geological factors. Soil surveys are generally required for development and reclamation approval of large pit and quarry operations. In agricultural areas with good soils (i.e., CLI Class 1 to Class 3 soils), a soil survey by a soils expert is recommended. Such information will help you effectively salvage topsoil and subsoil from your pit area, and successfully replace soil on your reclaimed sites.

The types and volumes of topsoil and subsoil that are available for reclamation will determine the best methods of soil replacement and handling, as well as the need for special treatments such as fertilization (see below).

Soil Salvaging

As discussed in Chapter 2, you are required to salvage and stockpile topsoil and overburden in separate piles. You also should use erosion control measures on these stockpiles to limit losses of topsoil by wind and water.

Progressive Reclamation and Development

When you are reclaiming an area for agriculture, progressive reclamation and development is a valuable tool because it helps reduce the size of disturbed areas within your property (see Chapter 2). If portions of your pit are only operated for a one year period, it is often possible to strip soil from an area, extract the sand or gravel resource, and restore agricultural production in only 3 to 4 years (Illustration 7).

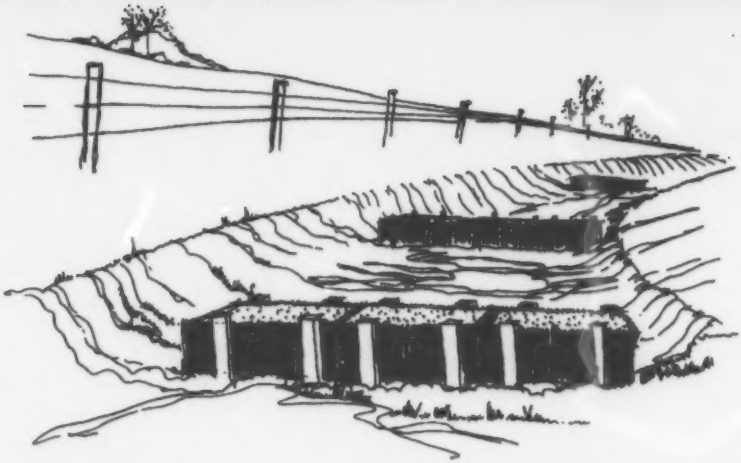


ILLUSTRATION 12, DRAINAGE DITCHES IN AGRICULTURAL AREAS SHOULD HAVE SLOPES NO STEEPER THAN 10:1 TO ALLOW PASSAGE OF FARM EQUIPMENT. HAY BALES CAN BE USED TO LIMIT EROSION OF THE DRAINAGE DITCHES AND TO TRAP SEDIMENT.

Shape, Size and Depth of Your Pit or Quarry

The dimensions of the pit are largely controlled by the geology of the sand and gravel resource, but will have a large effect on reclamation options and costs. Your preferred final grades and drainage should be considered when planning pit layout.

Farming efficiency is greatest when field shapes are rectangular and lack obstructions or severances (Illustration 11). If your reclaimed area is too small to use as a separate field, you may want to eventually incorporate the reclaimed areas into the adjacent fields. Don't forget to also plan for good access by farm equipment to the reclaimed area and adjacent fields.

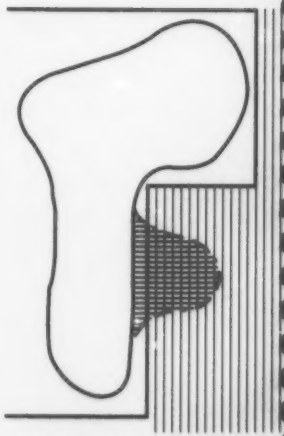


ILLUSTRATION 11, OBSTRUCTIONS TO FARMING EQUIPMENT CAN BE MINIMIZED BY AVOIDING UNUSUALLY SHAPED PITS (AS IN THE DARK SHADED AREA)

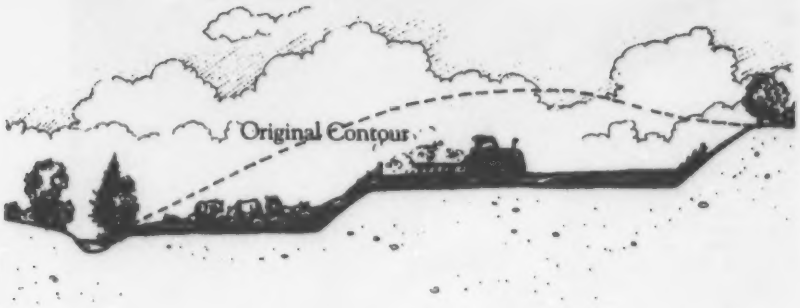


ILLUSTRATION 13, TERRACES, SWALES AND LOW RIDGES CAN BE USED TO MINIMIZE SOIL EROSION, WHILE STILL ALLOWING FARM USE

METHODS FOR RECLAMATION

Grading and Contouring

Soil erosion risk is the primary factor you should consider in selecting a final slope for your reclamation area. Farm equipment for cultivating, seeding and fertilizing, as well as heavier machinery for reclamation can work on slopes as steep as 3.5:1, but work more efficiently on flatter slopes. If you plan to develop your area for forage production or pasture, and occasional cultivation will be necessary, the maximum slope to reduce erosion risk should not exceed 5:1. Land intended for production of annual crops should have maximum slopes of 10:1 to avoid severe topsoil erosion, and to allow efficient machinery operation. Drainage ditches that will be farmed through should have maximum slopes of 10:1 to allow passage of machinery (Illustration 12).

You should also grade back any highwalls by knocking the top down and grading fill to within the preferred range of slopes. Note that topsoil must first be salvaged from the area to be resloped. Graded slopes should also be blended into adjacent undisturbed areas to prevent shelves or steep troughs.

As slope length increases, so does the soil erosion hazard. Uninterrupted slope lengths should be kept to a minimum. Terraces, swales, and low ridges can all be used to break up long slopes (Illustration 13).

PHOTO 14, SOIL RIPPING

Replacing Overburden

There are two major soil quality concerns that you should consider when replacing overburden:

- poor quality overburden (saline, very stony, etc.) should be replaced first and covered with better material; and
- over-compaction should be avoided or corrected by mechanically loosening or ripping the soil surface (Photo 14).

In order to get poor quality overburden at the bottom of the pit, you should identify, salvage and store it separately, and replace it separately. This requires careful planning. Compaction can be considerably reduced by dumping material in thick (1metre) lifts, minimizing running of scrapers or other machinery over levelled areas, and not spreading material when it is wet (Illustration 14).

If compaction does occur, ripping can improve soil conditions by:

- breaking up the surface crust of the overburden,
- increasing infiltration of water (this reduces runoff and erosion, and helps leach salts downward),
- creating a much better root zone, and
- bringing up stones that would surface later due to frost action and cultivation (Photo 14).

Roughening of the overburden surface prior to topsoil placement also helps to keep topsoil in place.

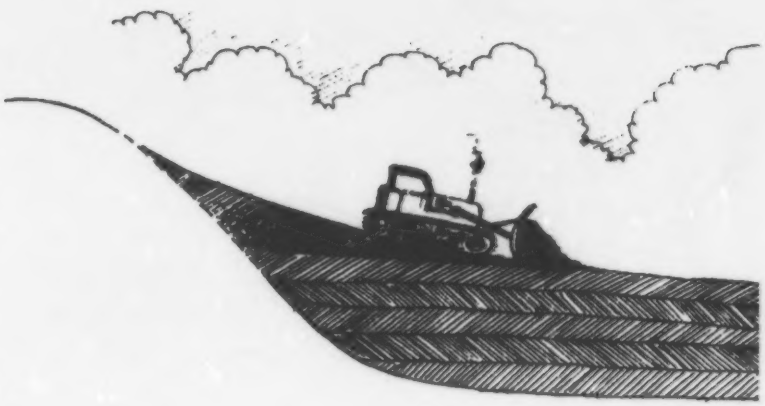


ILLUSTRATION 14, WHEN REPLACING OVERBURDEN IN YOUR PIT, PLACE IT IN THICK LIFTS TO MINIMIZE COMPACTION

Site Drainage

Control and re-establishment of site drainage is an important component of reclaiming for agriculture, in order to:

- minimize erosion, soil loss and sedimentation that can result from overland flow and channel flow through reclaimed areas;
- control flooding or ponding, and
- minimize obstacles to farming equipment.

Because runoff water may flow to or from adjacent properties, and affect the entire drainage basin or sub-basin, it is important that you establish a good drainage system for your reclaimed area.

If you are using progressive reclamation, site drainage is also important in lowering water table levels in work areas and in re-cycling ponded water for site use. Progressive reclamation and development procedures also reduce the need for complex runoff control measures over large areas.

You can re-establish site drainage in agricultural areas by a number of methods, including:

- Interceptor drains and grassed water runs to slow the velocity of runoff water and prevent severe erosion;
- Use of temporary diversion drainage on newly topsoiled and seeded areas; and
- Sedimentation impoundments to protect water quality in downstream areas. The size and location of impoundments is determined by runoff volumes, erosion rates, and required retention times.

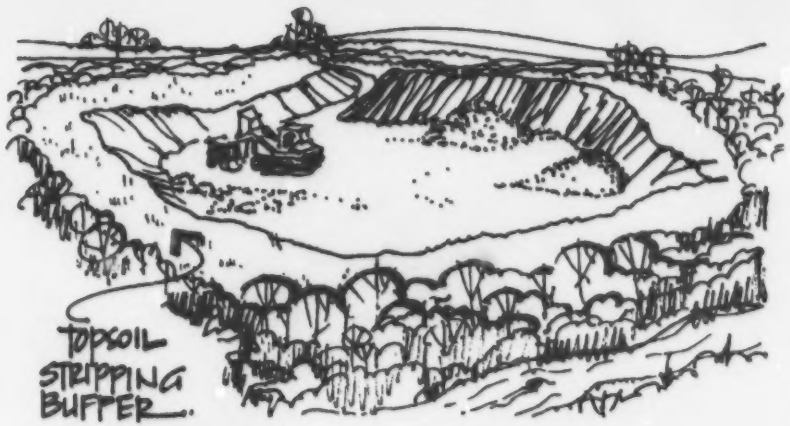


ILLUSTRATION 15, LEAVE BUFFER STRIPS OF NATIVE VEGETATION TO PROTECT ADJACENT LAND AND WATER, AS WELL AS TO VISUALLY SCREEN YOUR OPERATION

Drainage systems for operating pits are almost always enclosed, feeding back to a central pond in the bottom of the pit. If you want to drain a pit across other land, you must obtain a license from Alberta Environment. The number of ponds should be limited on agricultural land to reduce obstacles, and to provide one stable water supply source for cattle or other on-farm uses (domestic supply, supplemental irrigation, fish farming).

You should leave buffer strips of undisturbed vegetation along streams, reservoirs, roads, and property lines to help slow runoff velocity, trap sediment and promote infiltration (Illustration 15). The need for site drainage structures can also be reduced by ripping compacted overburden before you apply topsoil. Such measures increase infiltration rates and reduce runoff. Ripping is most effective if it follows the contours across the slope.

ILLUSTRATION 16, SOIL EROSION ON SLOPES CAN BE MINIMIZED BY LEAVING CLEAT MARKS AND RIDGES ACROSS THE SLOPE

Replacing Topsoil

Topsoil is the very "essence of farming". It must be carefully handled and replaced to meet current reclamation guidelines, and to ensure the best reclamation success for agriculture. Topsoil replacement requires planning and careful quality control to get maximum results. As a general rule of thumb, you should match the depth of topsoil replacement to "what was there before".

You should replace topsoil in all areas intended for agricultural use, and where it is needed to establish good grass cover for erosion control. You should not waste good topsoil in areas that will be below water table levels or flooded during most of the growing season. Topsoil should also not be wasted in saline seep areas.

To avoid compaction of topsoil, you should minimize machine traffic as much as possible, and **not** work it when it is wet. Heavy traffic breaks down soil structure, making it more erodible.

Once you have replaced topsoil on your reclamation site, it should be protected from erosion through proper runoff control and establishment of plant cover (see Planting Cover Crops below). When finishing off the topsoil placement, you **should not** back-blade to make a "nice, smooth" surface, as this usually results in severe erosion losses. Instead, you should leave track cleat marks or ridges and troughs across the slope to slow runoff velocity (Illustration 16). Surface roughness and plant cover reduce water and wind erosion. Erosion losses can also be minimized by keeping disturbed areas as small as possible.

PHOTO 15, BROADCAST SEEDING

Planting Cover Crops

Your selection of seed mixes will depend largely on your intended land use: pasture, forage crop or short-term cover for annually cultivated land. Climate and site moisture will also affect your choice of seed mix. Mixtures of grass species or grasses and legumes produce hardy, long-lived stands, provide long grazing periods, and have a better establishment chance than single species stands.

You can seed by one of two basic methods — broadcast and drill seeding (Photos 15 & 16). Hydroseeding and aerial seeding are variations of the broadcast method. Drill seeding is preferred where slopes permit. Grass drills work best for seeding grasses and legumes. Grain drills place grass seed too deep, but can be lifted to broadcast grass seed. With broadcast seeding, your "catch" will improve if you cover the seed by harrowing, mulching, or some other method.

Row spacing and seeding rates vary by soil zone and by forage crop. In general, seeding rates (by drill) should be approximately 100 to 200 viable seeds/m^2. This results in a stand of 20 to 40 plants/square metre, which is a good density for forage stands. Twice as much seed could be used for erosion control on a difficult site. However, you should avoid excessive seeding rates, as they result in overly-dense, stagnant stands. Seeding rates for the broadcast method are twice that recommended for drill seeding.

PHOTO 16, DRILL SEEDING

Cover crops, such as barley or oats, are used because they germinate and develop rapidly. If seeded in mid to late summer, they provide cover by fall but do not set seed, and will not take over the stand the following year. Seeding rate of these cereals is best at about 40 kg/ha (1 bu/ac), which is about half of the normal rate for a crop.

Time of seeding varies by site and type of seed, but is usually best in spring (mid-May). In most cases, you should seed your reclamation area as soon as possible to minimize surface erosion. Areas with poor catch should be reseeded.

Fertilizing helps to establish and maintain a stand for a few years. You should usually use a high phosphate fertilizer, as it helps establish ground–cover more than nitrogen, and phosphate lasts in the soil. Your local agriculture or forestry office can assist you in soil testing and in identifying the most appropriate fertilizer. In many areas, an application of 110 kg/ha (100 lb/ac) of 11-55-0 may be suitable.

OTHER SOURCES OF INFORMATION

For additional information on reclaiming land for agriculture, write or phone:

Alberta Agriculture,
Conservation and Development Branch,
2nd Floor, J.G. O'Donoghue Building,
7000 - 113th Street,
Edmonton, Alberta
T6H 5T6
Phone: (403) 422-4385

Land Reclamation Division,
Alberta Environment,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Within Alberta, you can call these government agencies toll free through the R.I.T.E. Telephone Network. See Chapter 10 for a listing of the R.I.T.E. Telephone Number in your area.

Other agencies which may be able to provide you with information include:

Agricultural Service Board, and
Your local County or Municipal District

Books and Reports

1. Soil Quality Criteria Relative to Disturbance and Reclamation. Revised edition, 1987. Published by Alberta Agriculture.

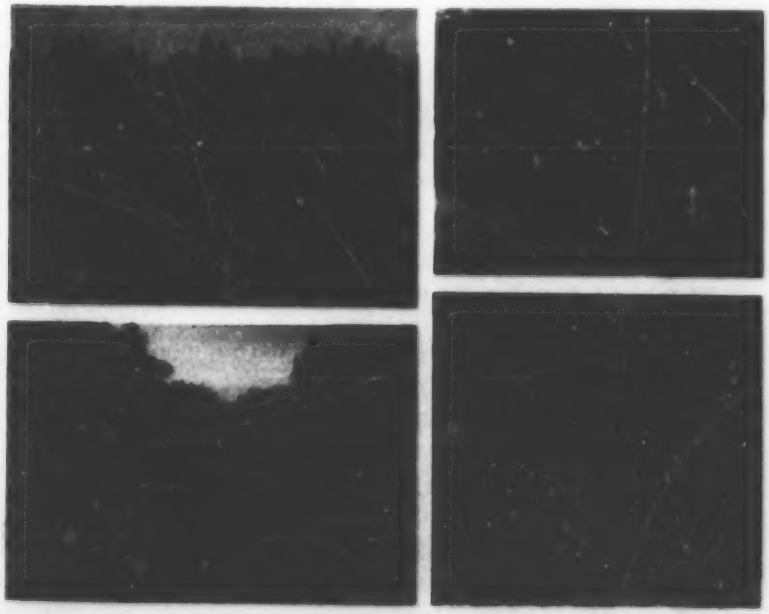
2. A Manual for Training Reclamation Inspectors in the Fundamentals of Soils and Revegetation. Soil and Water Conservation Society, 7515 Northeast Ankeny Road, Ankeny, Iowa 50021-9764.

3. A Manual for Training Reclamation Inspectors in the Fundamentals of Hydrology. Soil and Water Conservation Society, 7515 Northeast Ankeny Road, Ankeny, Iowa 50021-9764.

RECLAIMING LAND FOR FORESTRY

If you have selected forestry as the end land use for your pit or quarry, this chapter provides specific information on issues that may affect forestry uses on your property, including:

- Important considerations in reclaiming your site for forestry:
  - meeting timber management regulations,
  - adjacent land uses,
  - land use zoning,
  - shape, size and depth of your pit or quarry.
  - soil salvaging,
  - soil types and availability, and
  - progressive reclamation and development.
- Methods for reclamation:
  - grading,
  - ripping,
  - site drainage,
  - replacing topsoil,
  - selecting tree seedlings,
  - planting, and
  - managing reforestation areas.



IMPORTANT CONSIDERATIONS IN RECLAIMING YOUR SITE FOR FORESTRY

Meeting Timber Management Regulations

If merchantable timber or productive forest on public lands is removed during extraction, you will be required to meet the reforestation standards as outlined in the Timber Management Regulations for Alberta. Contact Alberta Forest Service for additional information (see Chapter 10).

Adjacent Land Uses

Because of the long-term requirements of forest production, you should carefully consider the surrounding land uses. A forestry land use is most suitable where the adjacent land use is commercial forestry or natural forest growth. Zoning maps should be consulted, as they may indicate that forestry is the best use for that area. Maps such as these include the Canada Land Inventory Series available from Maps Alberta (Alberta Forestry, Lands and Wildlife) or the federal Department of Environment.

If your reclamation area is on the edge of a city, commercial revenue from timber production is generally not feasible. You may instead want to cultivate Christmas trees or nursery seedlings.

Land Use Zoning

Before planning and developing your site for forestry, be sure to review local ordinances and current and proposed Land Use Zoning regulations. These regulations, established by the Regional Planning District offices and the Provincial Government, will allow you to determine if forestry uses will be permitted on your site, and the types of restrictions that may apply.

PHOTO 17, A RECLAIMED OPERATION IN A FOREST MANAGEMENT AREA

Shape, Size, and Depth of Your Pit or Quarry

The size of your pit or quarry is an important factor in deciding whether or not you should consider forestry as an end use. Pits or quarries less than 2 hectares in size should not be considered for forest production, simply because it is not economical to harvest on such a small area. However, if your pit or quarry is already part of a larger, adjacent cut block, it could be incorporated in this cut block following reclamation and replanting with suitable species of trees (Photo 17).

The shape of your pit or quarry is not necessarily a limiting factor for forest production. However, rectangular or square pits are often more accessible to machinery if mechanical planting or harvesting is being considered. Convoluted and irregular edges, while attractive to wildlife, can be difficult to navigate with machinery.

The depth of the pit or quarry may also limit forest production. In general, slopes of 5:1 or steeper are not feasible for tree planting, growth, or easy harvesting. If a commercial forestry end use is desired, highwalls should be backsloped to shallower slopes. If in doubt, contact the Alberta Forest Service. Deeper pits or quarries are also closer to the permanent water table and may be less well drained. As many commercial tree species will not tolerate excessive soil moisture, backfilling of the pit or quarry with overburden may be necessary to provide an adequately drained root zone for seedlings and trees.

Timber Salvage

During clearing and grubbing operations, merchantable timber should be salvaged from your development area. On public lands, you will likely be required to do so. Salvaged timber can be used as saw logs, building material, firewood or wood chips for mulching and composting.

Soil Salvaging

Regardless of the end use, proper soil salvaging is a very important component of your reclamation operation. However, in many of the forested areas of Alberta, there is little topsoil. As a result, you should try to ***separately*** strip and stockpile the topsoils (the duff layer and surface mineral soil) and overburden. Because of the value of the topsoil, it is very important that the topsoils are not mixed with the overburden.

If possible, the duff layer and the top 30 cm of surface mineral soil should be stripped and stockpiled together. The mixing of these upper layers of soil will provide the best soil conditions possible for the top replacement layer:

- The organic material present in the duff layer will mix with the top 30 cm of mineral soil during the stripping process resulting in a soil layer with some organic material; and
- The presence of organic material in the "topsoil" layer will improve soil texture, and increase water-holding capability and the supply and availability of nutrients.

You should pile topsoil and overburden in low mounds to prevent soil compaction and to maintain soil productivity. If the pit or quarry is in a forested area, space should be left between all stockpiles and the surrounding forest to allow equipment to get behind the stockpiles and push the material back into the pit. Heavy equipment should not be run over the soil stockpiles. If you will be stockpiling soil for more than one growing season, the stockpiles should be seeded with a groundcover to prevent erosion.

Soil Types and Availability

If you have selected forestry as your end land use, a soil survey will help in planning your operation. At minimum, you should know something about the soil horizons in the pit or quarry area. Soil horizons can be easily viewed at exposed areas such as road cuts or by digging a small test hole. Important characteristics of the soil include texture, colour, depth, and moisture:

- For a healthy productive forest, at least 0.5 metres of soil is required over the bedrock or permanent water table. Deeper, moister, but well-drained soil layers are preferred and will increase the potential for good tree growth.
- If the soils are sandy, they must be deeper to provide adequate moisture and nutrients.
- Soils should be loose enough for water, root movement and root aeration, but solid enough to anchor trees.
- Saline or sodic soil materials are very limiting to tree growth and should not be considered for forestry production.

Progressive Reclamation and Development

Unless your reclaimed area is to be used for Christmas trees or development of a fruit orchard, progressive tree planting in areas smaller than 4 ha is impractical. If your area is large enough, however, different sections of the pit or quarry (larger than 4 ha in size) can be developed as individual reforestation projects.

Regardless of the size of the reclamation area, you should progressively grade your site, replace and rip the overburden, and replace the topsoil while equipment is available (see Chapter 2). You should also establish a temporary grass cover on these areas to control erosion.

METHODS FOR RECLAMATION

Grading

Once you have completed your extraction operation, you will need to grade the site, prior to replacing and ripping the overburden, and replacing the topsoil. Unless your pit or quarry is very small (less than 1 ha), you should progressively complete these tasks for each major section of the operation.

For a forestry end use, it is best if you reshape the pit or quarry to form a gentle land contour with slopes no steeper than 5:1.(Illustration 4). Reshaping should minimize slope angles and ridges which cause wind-scouring and erosion. Once overburden is placed back over the pit contours, it is often necessary to recontour the final slopes to enhance drainage and to provide access for ripping, topsoil placement and tree planting.

Ripping

As the use of heavy equipment during the replacement and grading of overburden tends to compact the ground, you should loosen the overburden surface by ripping. Soil compaction tends to break down the soil structure, reduces the pore space of the soil, and forms a tight barrier to the percolation of moisture and nutrients. The decreased pore space reduces the water holding capacity of the soil. It also hinders penetration and water and nutrient uptake by roots.

To reduce the effects of soil compaction, you can work your reclamation site with deep rippers or plows. You should work along the contours, preferably to a depth of at least 0.5 metres. In general, the deeper and more extensive the ripping and plowing, the greater the success of seedling establishment and tree growth. However, ripping should not be deeper than the good quality subsoil to avoid contamination by underlying layers.

Site Drainage

Site drainage is extremely important for preventing erosion, and should be part of the recontouring phase of the reclamation work. Where possible, you should grade your site along the contours to enhance snow and rain collection and absorption.

On the lee side of ridges, you should try to provide steeper, protected slopes where snow can build-up. These areas can provide an important source of moisture for trees. However, avoid ponding of surface water, as excessive soil moisture can limit tree growth.

On any slopes within your site, you should develop surface drainage features such as terraces to guard against erosion. Try not to create features such as gullies and down-slope grading that encourage erosion.

Replacing Topsoil

Once you have completed recontouring and ripping your site, you are required to replace the topsoil. As discussed above, use of heavy equipment on replaced topsoil should be minimized to prevent soil compaction. When finishing off the topsoil placement, you should leave cleat marks or ridges and troughs across the slope to slow runoff velocity (Illustration 16).

Selecting Tree Seedlings

You should select trees for your site based on site conditions and your desired market or use for the forest products. If more than one species will meet your requirements, then site conditions should determine the choice of species. On large reclamation areas, planting of different species may avoid the dangers of disease outbreaks in a single species plantation, while also providing better habitat for wildlife. Your local Forest Service office can assist you in selecting the best forest use and tree species for your site.

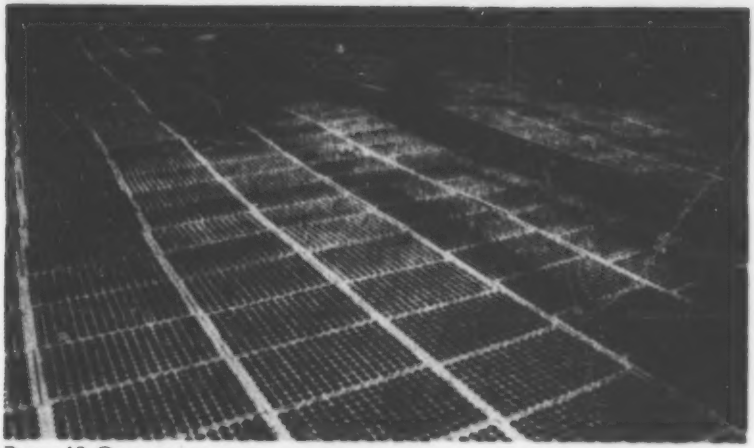


PHOTO 18, CONTAINERIZED TREE AND SHRUB SEEDLINGS

Seedlings may be obtained commercially as either containerized stock (roots and soil held in reusable blocks or degradable tubes) or bare root stock (loosely packed in bundles) (Photos 18 & 19). In general, purchase costs for containerized seedlings are higher than bare root stock.

Containerized stock has the following advantages:

- Soil remains on roots during transplanting, packing, transportation, and planting.
- Fine roots are protected and provided with an immediate medium of moisture and nutrients for growth.
- Planting is swifter and more flexible as to timing of planting.

However, containerized stock is expensive to ship and handle. Some degradable containers may restrict root growth, accelerate drying out of seedlings, and increase susceptiblity to frost heaving.

Bare-root seedlings, while requiring more care in handling, have the following advantages:

- Inexpensive to ship and handle.
- Can be handled while dormant, and less hardening is required to withstand cold weather.
- Fewer problems in the handling of stock during planting.

For good seedling survival it is very important that bare-root stock be in good condition, and that it be handled carefully while in storage and during planting. As roots can dry out quickly, and be damaged during handling and planting, stock must be kept moist and in the shade until planted.

The decision between containerized stock and bareroot stock is up to you. There is no clear-cut evidence that either type is better. Some evidence suggests that containerized stock has greater transplant survival in conifers

PHOTO 19, BARE ROOT STOCK

PHOTO 20, SHADE HOUSE

PHOTO 21, PLANTING BY HAND

and bareroot stock has greater survival for deciduous trees. Before you make a decision be sure that you check up on the complete costs of either type.

Planting of Groundcovers, Shrubs and Trees

If a cover crop has been planted for erosion control, you should cultivate patches or rows for planting of the tree seedlings. During establishment of the seedlings, grasses should be kept a minimum of 0.5 metres from the tree stem.

The most critical factor in any planting operation is to minimize the time between shipping and planting. If you cannot plant the seedlings immediately, you should store them in a cool, shady place (Photo 20). At no time should the roots of seedlings be allowed to dry out.

You can plant trees by hand or by machine (Photos 21 & 22). Hand planting of trees is time consuming and labour intensive, but is likely to be suitable for most reclamation areas. In addition, the survival of seedlings is usually greater with hand planting than with machine planting. Machine planting is generally suitable only on larger areas (more than 4 ha) with flat, even terrain.

Spacing of tree seedlings within the plantation can be variable. In general, spacing of 2.1 metres between rows and 1.8 metres between seedlings will permit equipment to move between rows without damaging seedlings. This spacing represents 2,545 seedlings per hectare. Do not overcrowd seedlings, as this can be detrimental to the growth and survival of trees in your reclamation area.

PHOTO 22, MACHINE PLANTING

Managing Reforestation Areas

Management requirements are likely to include weeding, pest control, fertilizing, and thinning. As some management techniques may not be permitted on public lands, you should contact your local Forest Service office for advice.

Weed Control

Weedy vegetation, as well as grasses and forbs, can out compete young seedlings, and needs to be kept clear from the tree stem for at least 0.5 metres. While you may do this by cultivation, careful use of herbicides represents the most efficient method for weed control. Use of herbicides should be undertaken with extreme caution as damage can easily be done to the trees, wildlife, fish and humans. Information on herbicides can be obtained from your local office of Alberta Forestry, Lands and Wildlife, Alberta Environment or Alberta Agriculture.

Pest Control

Insects and disease may pose problems for your tree plantation. There are many effective methods for control including biological control, pesticides, and different land management practices. Information on preferred control methods can be obtained from the district representatives of Alberta Forestry, Lands and Wildlife, Alberta Environment or Alberta Agriculture.

Thinning

Thinning is often required to remove injured or sickly trees, thereby reducing competition for the stronger trees. Thinning may take place at any stage of plantation growth. Large scale thinning of a plantation at later stages of growth (25 to 30 years) may provide some products such as pickets or wood chips.

Fertilization

Fertilization may be useful in improving the productivity of your plantation, particularly during the early growth stage (4 to 5 years) of the young seedlings. You should not fertilize prior to this time, as the seedlings' roots cannot make adequate use of fertilizers, and weedy vegetation will benefit instead.

Firebreaks

In large reclaimed areas, or where your reclaimed area abuts natural forest stands, you may want to develop and maintain firebreaks. Firebreaks can be provided by access roads through the plantation, and are best put in place from the beginning of the operation. Firebreaks should run perpendicular to the prevailing winds.

OTHER SOURCES OF INFORMATION

For additional information on reclaiming land for forestry, write or phone:

Forest Land Use Branch,
Alberta Forest Service,
6th Floor, Bramalea Building,
9920 - 108th Street,
Edmonton, Alberta
T5K 2M4
Phone: (403) 427-3582

Land Management Branch,
Alberta Public Lands Division,
4th Floor, South Petroleum Plaza,
9915 - 108th Street,
Edmonton, Alberta
T5K 2G8
Phone: (403) 427-6597

Land Reclamation Division, (for private land)
Alberta Environment,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Within Alberta, you can call these government agencies toll free through the R.I.T.E. Telephone Network. See Chapter 10 for a listing of the R.I.T.E. Telephone Number in your area.

RECLAIMING LAND FOR WILDLIFE HABITAT

If you have selected wildlife habitat as the end land use for your pit or quarry, or as a secondary use to include with other land uses, this chapter provides specific information on issues that may affect your choice of wildlife habitat:

- Important factors to consider in reclaiming your site for wildlife:
  - adjacent land uses,
  - land use zoning.
  - public access,
  - types of wildlife,
  - shape, size and depth of your pit or quarry,
  - highwalls,
  - conserving topsoil,
  - salvaging shrubs and small trees,
  - water sources, and
  - progressive reclamation and development.
- A general approach to wildlife habitat reclamation
- Restoring upland habitats
- Restoring wetland habitats

One of the advantages of a wildlife habitat based approach to reclamation of your pit or quarry is that it can often be achieved through only minor changes to standard reclamation procedures.

PHOTO 23, FENCING TO PROTECT NEW HABITAT AREAS

Wildlife habitat reclamation can be adapted to almost any area and almost any type of disturbance you may encounter. As habitat reclamation can often be implemented in sites where agriculture, forestry, or residential/commercial uses are impractical, it is often a more viable and economical objective. The adaptability and flexibility of wildlife habitat reclamation offers you the ability to develop valuable islands of habitat within otherwise simplistic landscapes. Even if other end uses are the principle objective of your reclamation project, the creation or enhancement of wildlife habitat may be included as a secondary objective.

IMPORTANT CONSIDERATIONS IN RECLAIMING YOUR SITE FOR WILDLIFE HABITAT

Adjacent Land Uses

While reclamation for wildlife habitat, particularly upland habitat, can take place in a remote wilderness area or on the periphery of a city, potential conflicts with adjacent land uses must be taken into consideration.

Typical problems are nuisance related, such as damage to agricultural crops by waterfowl, or browsing of ornamental plants and shelterbelts by deer. Some adjacent land uses such as cattle grazing or residential development may also detrimentally affect wildlife habitat projects. In some of these cases, it may be necessary to install fencing around the habitat project to protect vegetation from overgrazing and minimize harassment of wildlife (Photo 23). If habitat projects are located immediately adjacent to major roadways or railways, you should also consider the potential for roadkills. Fencing can sometimes be used to direct animals away from dangerous crossing areas along highways and railways.

Land Use Zoning

Before planning and developing your site, be sure to review local ordinances and current and proposed Land Use Zoning regulations. These regulations, established by the Regional Planning District offices and the Provincial Government, will allow you to determine if development of wildlife habitat will be permitted on your site.

Public Access

Wildlife habitat projects which have been funded with public money (e.g., government grants) or with money from organizations such as Ducks Unlimited or Wildlife Habitat Canada may require that public access be provided for uses such as hiking, hunting or bird watching. If you are considering external funding, it is advisable to check on any binding requirements before obtaining monies from certain organizations.

Types of Wildlife

Regional and local differences exist in the distribution and abundance of wildlife. It is important to know what wildlife you have in your area, and which species will respond best to the likely conditions in your reclamation area. In general, your habitat project should be aimed at benefitting those species which you want to encourage, and are common in your region. However, in some special cases, you may be able to develop habitat for wildlife that are endangered or threatened. Suggestions for selecting a wildlife species as a focus for your reclamation project are provided later in this chapter.

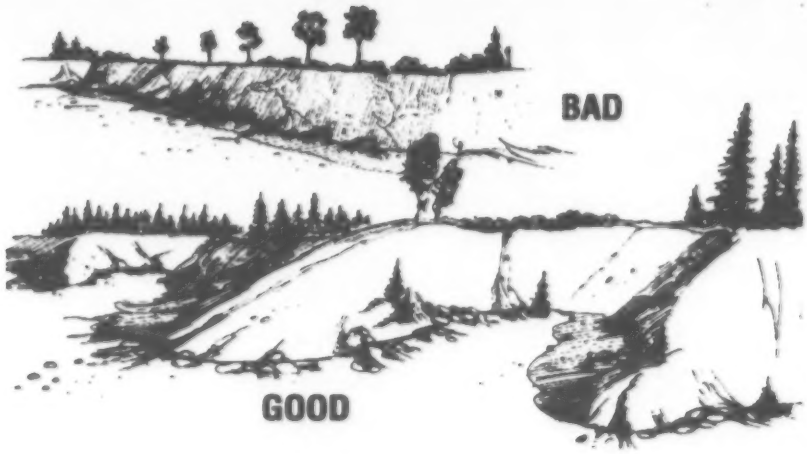


ILLUSTRATION 17. PITS OR QUARRIES WITH IRREGULARLY SHAPED EDGES AND IRREGULAR CONTOURS ARE PREFERRED OVER STRAIGHT EDGED SITES FOR DEVELOPMENT OF WILDLIFE HABITAT

Shape, Size and Depth of Your Pit or Quarry

Virtually any shape, size or depth of a pit or quarry can be used for wildlife habitat. The physical characteristics of the site are limiting only to the type of wildlife habitat that might be developed in your pit or quarry.

If your pit or quarry is oddly shaped with variable depths and rough and irregular contours, it is probably already well on its way to becoming good habitat (Illustration 17). In many cases, the more different landforms you can keep or develop on your site, the more useful it will be to wildlife.

The size of your reclamation area, however, may limit the types of wildlife that can or will use the site. Larger wildlife such as deer and elk require large blocks (10 ha or more) of trees and shrubs for food and cover, as well as safe escape routes. Smaller wildlife such as birds, rabbits and ground squirrels will use almost any size or type of pit or quarry.

Highwalls

If the highwalls within your pit or quarry are stable, they may provide important habitat for some birds of prey. To be useful, highwalls must be composed of stable, rock faces. Soft and loose rock material will easily erode or slump. If you plan to retain a stable highwall as part of your reclamation plan, be sure to consider safety precautions such as signage or restriction of public access. You will have to obtain permission from the either Alberta Environment (private lands) or Alberta Forestry, Lands and Wildlife (public lands) to retain a highwall.

Conserving Topsoil

As described in Chapter 2, it is important that you carefully and separately salvage and stockpile topsoil and overburden for later use in progressive reclamation of your site.

Salvaging Shrubs and Small Trees

Time, money, and effort can be reduced by salvaging trees, shrubs and groundcovers from your site (Photo 24), preferably during early spring or late fall.

If you salvage shrubs and small trees during the preparation of your pit or the next phase of your pit operation, they should be replanted as soon as possible. Trees and shrubs from the immediate site will provide plants that are well adapted to the site conditions. Salvaging may also enhance the revegetation of your site, as well as reduce the total cost for planting.

Water Sources

Water is a very important consideration in developing and improving wildlife habitat. Most wildlife require open water sources as a component of, or close to their habitat.

If your pit is excavated below the level of the permanent water table, water will pond in the bottom of the pit. If you have river or stream front property, you may be able to pump water from a nearby channel, but you must apply for and obtain a water permit. In irrigation areas, you may be able to obtain permission to run water from nearby irrigation canals. Diversion of water from natural channels is more complicated. In general, you may not divert water or construct works that divert, impede or otherwise interfere with a natural water course unless authorized. Contact the Water Resources Administration Division of Alberta Environment for more information.

PHOTO 24, TREES AND SHRUBS CAN BE SALVAGED FROM PROPOSED PIT OR QUARRY AREAS AND REPLANTED IN RECLAIMED SITES

Progressive Reclamation and Development

As described in Chapter 2, progressive reclamation and development of your operation is strongly recommended. From a wildlife perspective, progressive development and reclamation will provide wildlife with habitat of different ages. This greatly improves habitat diversity for wildlife. Salvaging of trees and shrubs is also feasible, as trees and shrubs removed during development of new sections can be directly planted in reclaimed areas.

A GENERAL APPROACH TO WILDLIFE HABITAT RECLAMATION

Background

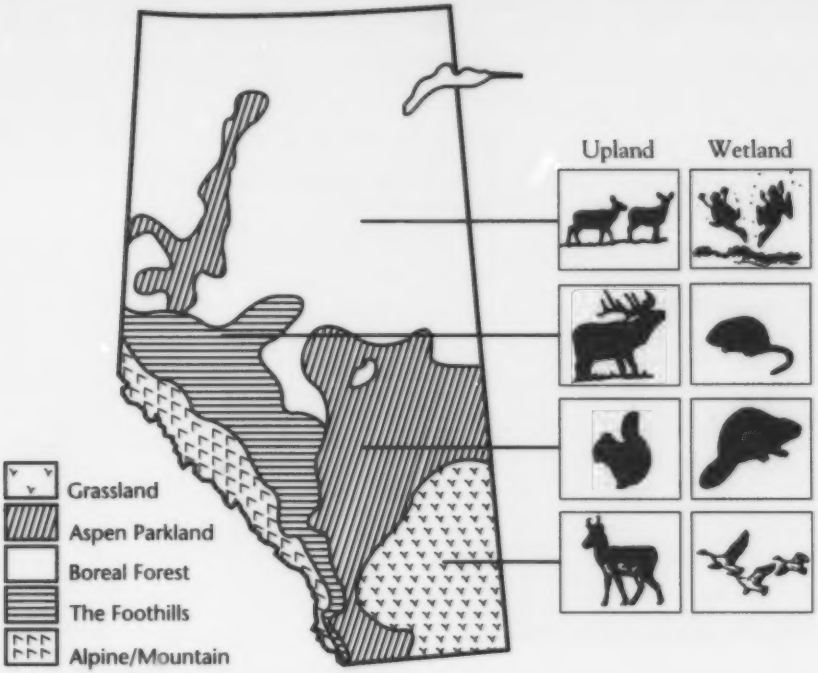
As many components in a reclamation plan are suitable for both upland habitat and wetland habitat, a general background is presented here which explains some concepts of reclamation planning and reclamation methods which are common to both upland and wetland habitat. After you have reviewed this section, you should review the individual sections on upland and wetland habitat for more detailed information on these habitat types.

Key Wildlife: A Focus for Your Plan

Before you design your pit and reclamation plan, you should ask yourself "What wildlife is present now?", and "What wildlife would I like to eventually have on my reclaimed areas?"

Certain wildlife species, such as deer or antelope, are quite selective in their habitat requirements. Other wildlife such as songbirds or small mammals are less selective, and will be at home, regardless of adjacent land uses, as long as their basic requirements of food and cover are available.

- To simplify the design of your reclamation plan, only a few wildlife species, known as key species, should be considered as a focus of the plan.
- Key wildlife species must be carefully chosen, and should be common in adjacent areas. By providing habitat for one or more key species, you will also be providing habitat for a host of other species. For example, if you develop habitat for waterfowl, the same area is also likely to support amphibians, reptiles, songbirds, and muskrat.



KEY SPECIES OF WILDLIFE FOR DIFFERENT REGIONS OF ALBERTA

Your local Fish and Wildlife representatives can assist you in the selection of key wildlife species for a site. Your reclamation program may even be able to add to existing or proposed wildlife management programs.

Suggested key wildlife species for the different regions of Alberta (see Chapter 3) are shown in the following chart:

Biogeographical Region	Representative Species	
	Upland	**Wetland**
Prairie Grassland	pronghorn antelope white–tail deer Sharp-tailed grouse	 dabbling ducks Canada goose
Aspen Parkland	mule deer sharp-tailed grouse red squirrel	 dabbling ducks beaver
Boreal Forest	mule deer moose sharp-tailed grouse	 dabbling ducks beaver
Foothills	snowshoe hare moose elk spruce grouse	 beaver muskrat

CHART 3: KEY SPECIES OF WILDLIFE FOR RECLAMATION PLANNING IN ALBERTA.

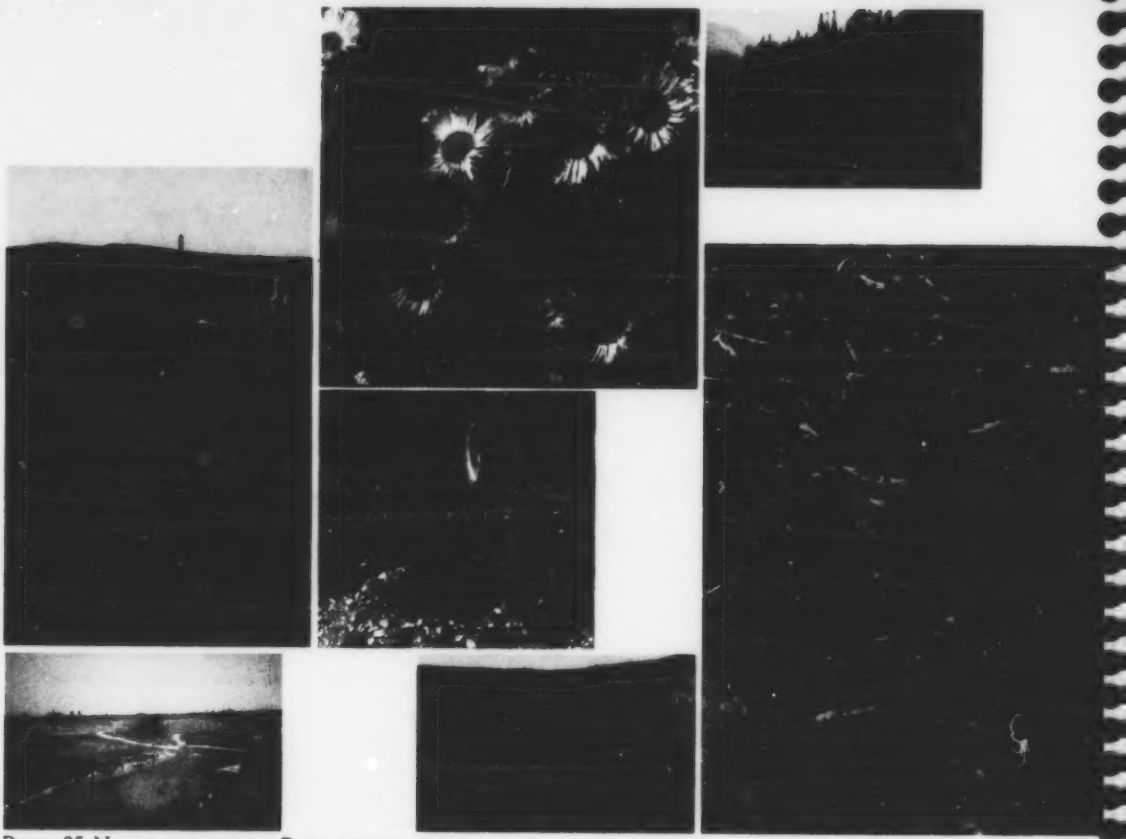


PHOTO 25, NATIVE AND DOMESTIC PLANT SPECIES

Re-establishing Plant Cover on Your Site

Once you have finished recontouring your site, and have replaced the overburden and topsoil, the establishment of a self-sustaining plant cover should be your next objective. It is the last essential element of wildlife habitat reclamation.

Revegetation for wildlife must consider several factors, including the seasonal needs of your key wildlife species for food and cover, the size of the reclamation area, soil types and moisture, the arrangement of plant communities within your site, and the placement and spacing of plants within each community. The potential for soil erosion (see Chapter 2) should also be considered.

In designing your revegetation plan, there are two important issues you should consider:

- the best approach for revegetation, and
- the use of domestic and native plants.

Your Best Approach to Revegetation

There are two effective and efficient approaches to re-establishing plant cover on your site:

- using native plant species, you can establish an early stage of a desired plant community; or
- using a mixture of native and domestic plants you can establish a plant cover with good potential for developing into the desired plant community (Photo 25).

Invasion of native trees, shrubs, grasses, and forbs from adjacent areas is important in either of these approaches. The combinations of domestic and naturally-invading species result in many different stages of plant development that provide a good mixture and diversity of habitats with the least amount of effort and cost.

Other approaches for revegetation have been attempted such as the transplanting of large trees and shrubs to immediately provide habitat, or the development of exotic plant communities. In general, these approaches are costly, and are not very effective in providing good wildlife habitat.

Choosing Plants

Once you have chosen a key species for your reclamation project, you will want to select a variety of plants for use in your planting and seeding program. Obviously, any of the plants you select should be hardy to your area. As a rule of thumb, the trees, shrubs, and groundcovers that are present on and around your proposed site are likely to be the species best suited to your particular reclamation conditions.

You can use both native and domestic species of plants for reclamation. Native species are those that grow naturally in the local area. Domestic species are those which have been developed by selective breeding for special characteristics and growing conditions.

The use of native species in reclamation is becoming common, as commercial sources of seed, rootstock, and seedlings become available. Native species of plants have several advantages, as they:

- are better adapted to grow and reproduce under local conditions;
- require little maintenance to establish and flourish on a site; and
- have better long-term survival than domestic species, once established.

However, their initial growth often appears to be slower than domestic species, as they channel much of their first year energy into root growth.

Domestic species are not without their merits and are useful in some growing conditions:

- Many species have a faster initial growth of above-ground leaves and stalks than most native species, while also producing deep or fibrous roots. They therefore can often provide plant cover and erosion control within a period of only 2 to 3 months.
- Domestic species are readily available through local suppliers, and at lower initial cost, than native species.

Often domestic species may be used to swiftly establish a plant cover, while native species are included for long-term habitat re-establishment.

Although there is much controversy regarding the relative merits of native versus domestic species, there is little evidence to suggest that one is superior to the other for wildlife habitat reclamation. However, if you can obtain native seed at reasonable cost, it is a good choice as little long-term maintenance is required.

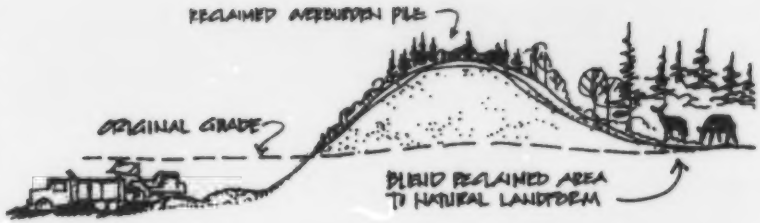


ILLUSTRATION 18, NATURAL LANDFORMS OR OVERBURDEN STOCKPILES CAN BE USED TO VISUALLY SCREEN THE PIT OR QUARRY FROM WILDLIFE

RESTORING UPLAND HABITATS

Grading and Contouring

In many situations, the rolling, hummocky terrain of an unreclaimed pit or quarry is more suitable for wildlife than recontoured landforms with little or no relief. However, some recontouring is generally necessary to control erosion, ensure that subsoil and topsoil can be maintained, and blend the reclaimed area with the natural landforms. As described below, final grading of your site should involve four basic steps.

- Determine how landforms can be graded and contoured to improve habitat diversity and site drainage, while maintaining rough areas which already provide potentially good landforms;
- Dump excess overburden in random patterns to enhance habitat diversity;
- Establish final site landforms with precautions to minimize soil erosion; and
- Prepare a suitable seed bed for groundcovers, shrubs and trees by ripping compacted overburden and replacing topsoil.

Habitat Diversity

Rough to rolling terrain provides a variety of landforms, increases snow accumulation, and helps retain rainfall and runoff, thus preventing surface erosion. It also provides a variety of sites for plants to establish, thus increasing plant diversity and the amount of habitat edge. Rolling landforms can also provide wildlife with visual protection from humans and predators (Illustration 18) during the first 5 to 10 years after reclamation when plant cover is still developing.

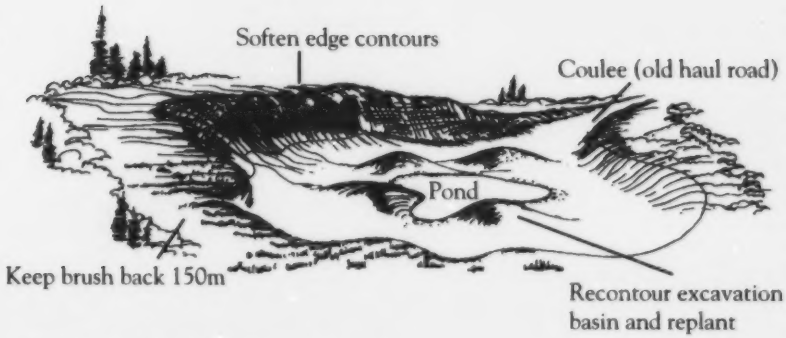


ILLUSTRATION 19, KNOB AND KETTLE TERRAIN AND BELOW-GRADE HAUL ROADS CAN BE USED TO DEVELOP IRREGULAR TERRAIN AND COULEES FOR WILDLIFE

Constructing New Landforms for Wildlife

Although some new landforms can be created for wildlife following the extraction phase, it is preferable to do so during the actual operation of your pit. There are a number of ways that you can create large landform features during the extraction of resources:

- Create an irregular, sinuous edge when opening and developing your pit (Illustration 17, pg 78).
- Use waste piles from the extraction of gravels and other resources to create a rolling "knob and kettle" terrain on the pit floor (Illustration 19);
- Regrade pit walls to provide slopes no steeper than 5:1 into the pit bottom. Keep slopes and contours irregular (Illustration 19).
- Recontour or design below-grade haul roads as coulee-like approaches to the pit bottom (Illustration 19). In some cases, you might even use these sites as inlets for small water courses.
- On flat areas or shallow slopes, existing depressions and irregularities should be maintained. These sites are particularly valuable in dry areas where collection of rainfall and snow melt can promote the growth of trees and shrubs.

By developing these features during the pit operation, you can usually create much larger landforms than through later recontouring activities. You can also minimize costs, materials handling, manpower requirements and equipment needs.

You may create rough and rolling terrain for wildlife by building-up or excavating new landforms during the recontouring and grading of [illegible] reclamation area.

ILLUSTRATION 20, IRREGULAR DUMPING OF EXCESS OVERBURDEN MATERIAL CAN BE USED TO CREATE LANDFORMS FOR WILDLIFE

Methods you can use to build-up new landforms include:

- Dumping of excess overburden in an irregular fashion on flatland areas or along existing slopes to create irregularly shaped rises or "knobs", 2 to 3 metres in height (Illustration 20). Ensure that any follow-up machine work will minimize the loss of surface irregularities on these areas.
- Regrading of existing site features, such as pit slopes or overburden waste piles, to create gradual ridges and terraces across the slope (Illustration 19). New features should run across the hill at right angles or very shallow angles. Depressions between the ridges may be suitable for development of poorly drained shrublands and grasslands.

Ripping

As discussed in Chapter 2, ripping and loosening of the subsoil and overburden reduces soil compaction, and provides a good base for topsoil placement.

Site Drainage

As with any land use, it is important that drainage patterns be developed within your reclaimed areas to minimize erosion problems, and direct surface runoff to areas where is is desired (see Chapter 2).

Water sources are an important habitat feature for most wildlife. Development or maintenance of ponds, wetlands and water courses on or in the vicinity of your reclamation project will usually ensure that wildlife will be attracted. Waterforms not only provide a ready source of open water, but they also create a variety of habitat types along their shorelines. (Methods to create large wetland areas and ponds are discussed in detail later in this chapter.)

Minor modifications in site drainage and recontouring can often provide small water holes for wildlife (Illustration 21). If depressions do not already exist within the pit floor, small depressions can be excavated with backhoes. You should then recontour the adjacent pit floor and slopes to channel surface runoff into these depressions. If the bottom of these depressions are leaky, you may need to line the area with clay to hold water. The shorelines should be seeded with grass species to prevent erosion and slumping. You may want to plant a few willows near the highwater zone of the water hole, but they will likely establish themselves.

To maximize use of these water holes by wildlife, you should ensure that fences or other structures do not obstruct wildlife access to the water hole. Most of the area within 10 to 15 metres of the water hole should be kept in grass cover to provide wildlife with a good line of sight when using the water hole. However, tree and shrub cover should be maintained or developed around the periphery of the grassed area to provide escape cover.

ILLUSTRATION 21, SMALL CHANGES IN SITE DRAINAGE AND EXCAVATIONS IN PIT AREAS CAN BE USED TO CREATE PONDS FOR WETLAND WILDLIFE

Replacing Overburden and Topsoil

To effectively develop upland habitat for wildlife, you will need to establish suitable, self-sustaining plant cover. To ensure good success in plant establishment, you must carefully replace overburden and topsoil, particularly in areas where dense tree and shrub cover is desired. Because uneven soil layers promote plant diversity, you should vary topsoil depths throughout your reclamation area. Methods for overburden and topsoil replacement are discussed in Chapter 2.

ILLUSTRATION 22, TREES AND SHRUBS SHOULD BE PLANTED ON COOL SLOPES THAT ARE PROTECTED FROM THE SUN AND THE PREVAILING WINDS

Planting and Establishing Upland Vegetation

Grasses and forbs provide an important food source for many wildlife species. Such cover is also important as nesting cover for some birds and as habitat for small mammals. Alberta Environment and the Alberta Fish and Wildlife Division can assist you in selecting the best groundcover seed mix to suit your key wildlife species and your location in the province. Grasses and forbs should not be seeded in areas where shrub and tree seedlings have been planted, as they will often compete for soil nutrients and water.

Trees and shrubs provide wildlife with food in the form of woody browse, berries, and leaves. They also provide wildlife with escape and hiding cover, shade from the sun, and protection from winter winds and low temperatures. A number of birds and small mammals may also nest in larger trees and shrubs.

In upland areas, trees and shrubs are best planted in locations where natural growth of the seedlings would normally occur. These locations include features such as north to westerly-facing slopes and gullies which are protected from the prevailing winds (Illustration 22). Seedlings or containerized stock are best planted by hand in areas of rough topography. You also may want to take cuttings from willows and poplars in adjacent wooded areas, for planting within your reclamation site. Contact the Alberta Forest Service for information on successfully growing trees and shrubs from cuttings.

In areas where elk and/or deer are abundant, it may be necessary to fence off your reclaimed site to prevent browsing of the newly planted ground covers, shrubs and trees. Most herbivorous (plant eating) wildlife prefer young plants, and can severely damage or pull out entire young plants while foraging.

Once your trees and shrubs are established, natural invasion of native shrubs and trees may also occur.

ILLUSTRATION 23, ISOLATED LEDGES AND HOLES ON STABLE ROCK FACES WITHIN YOUR PIT CAN BE DEVELOPED AS NESTING SITES FOR BIRDS OF PREY

Special Habitat Features

There are a number of special habitat features that you can develop to improve habitat conditions for wildlife. Many abrupt landform features on a site such as cliffs, gullies and badlands can be lost during site preparation and operations. However, other landform features such as highwalls, steep slopes, rock piles, and deadfall (dead trees) are created during site operations. Features such as these can often be retained for wildlife with only minimal modifications. They also can improve the scenic qualities of your site.

Highwalls

Rock highwalls are likely to be uncommon in most operations. However, if you do expose a stable rock highwall during your operation, it can provide excellent opportunities for wildlife habitat enhancement.

Isolated ledges and holes on the rock face can provide a variety of nesting sites for hawks, eagles, and other birds (Illustration 23). Overhanging cliff faces often provide important denning sites for other mammals such as foxes and coyotes. If features such as these are lacking, they can often be created or enhanced by dislodging rock chunks with a prybar, or chiselling or blasting small holes. Loose rock along the foot of a rock face should be left in place, as it provides habitat for a number of small mammals and birds.

Rockpiles

Large boulders are common waste materials in most sand and gravel operations. By retaining or building small piles of large rocks, you can create important habitat for small mammals, while also providing screening and hiding cover for larger mammals (Illustration 24). Rock piles are best located

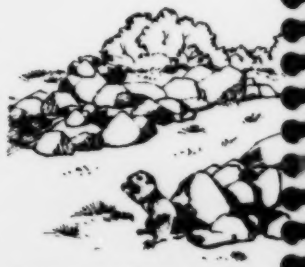


ILLUSTRATION 24, PILES OF LARGE ROCKS AND BOULDERS CAN BE USED TO PROVIDE BURROWS FOR SMALL MAMMALS, AS WELL AS PROTECTIVE COVER FOR LARGE WILDLIFE

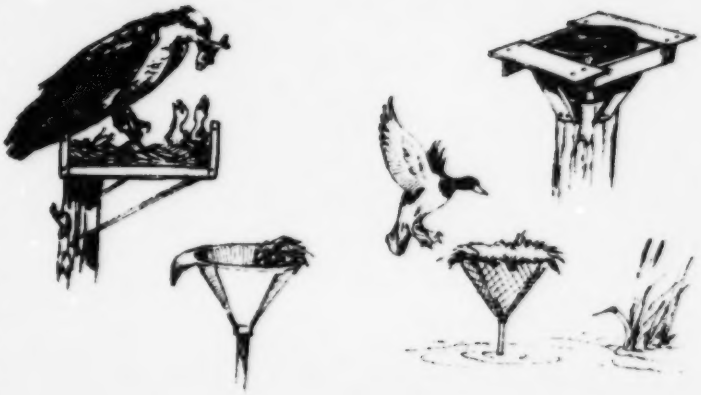


ILLUSTRATION 26, A VARIETY OF STRUCTURES CAN BE USED TO PROVIDE NESTING SITES FOR WATERFOWL AND OTHER BIRDS

along the bottom of small draws in the reclaimed pit or quarry and adjacent slopes. Rockpiles should be 1 to 4 metres in height, and loosely stacked to provide small nooks and crannies for small animals. Rock piles along ridges or hilltops may also be used for roosting by hawks and other birds of prey.

Brush Piles, Deadfall, and Snags

You can use brush piles and deadfall to create protective cover and perching sites for small animals and birds (Illustration 25). Snags can also be mounted upright in concrete, rocks or holes to provide nesting cavities for songbirds, or nesting sites for hawks, owls, and eagles (Illustration 26).

You may also want to construct artificial nest structures for birds of prey or cavity-nesting birds (Illustration 26). Bird houses and platforms can be mounted on wood or steel posts or nearby trees to provide new nesting and perching sites.

ILLUSTRATION 25, BRUSH PILES AND DEADFALL CAN BE PLACED TO PROVIDE PROTECTIVE COVER AND PERCHES FOR SMALL ANIMALS AND BIRDS

Management of Upland Habitat

Once you have completed seeding and planting your site, you should control access by livestock and people to prevent damage to the new ground–covers, and the tree and shrub seedlings. As a rule of thumb, no heavy traffic or grazing pressure should be permitted on a newly-reclaimed site for at least five years.

Fertilization of grass and other groundcovers will often speed the establishment of a self-sustaining groundcover. Watering of tree and shrub seedlings and groundcovers in the first 1 to 2 years after planting will greatly increase survival and growth.

RESTORING WETLAND HABITATS

During the operation of some pits, you may unintentionally create wetlands by excavating below the level of the permanent water table. Wetlands and ponds can add tremendously to a wildlife habitat project by providing a variety of new habitats and food sources for water-associated wildlife. The wetland margins and shorelines also provide highly productive habitat for upland and wetland wildlife.

An ideal wetland for wildlife should consist of equal scattered areas of aquatic plants and open water throughout the wetland. These mixtures of aquatic plants and open water provide wetland wildlife with abundant food, nesting sites, and protective cover. To be of value to nesting waterfowl, wetlands should also be surrounded with a wide margin of dense wetland and upland grasses.

Grading and Contouring

During the ongoing operation and reclamation of your site, try to recontour and grade to:

- provide site drainage features that will eventually channel surface runoff from the site and its surrounding area into the wetland, and
- create new landforms, above and below the waterline, such as irregular pond bottoms, islands, peninsulas, contoured banks, and mounds (Photo 26).

In wetland habitat, as in upland habitat, the greater the diversity of landforms, the greater the potential for wildlife use. As wetlands require water, grading and contouring of your site should enhance its water capturing capabilities. Wherever possible, grading and contouring should create gently sloping drainages towards the wetland.

PHOTO 26, PITS CAN OFTEN BE RECLAIMED AS WETLANDS FOR WILDLIFE

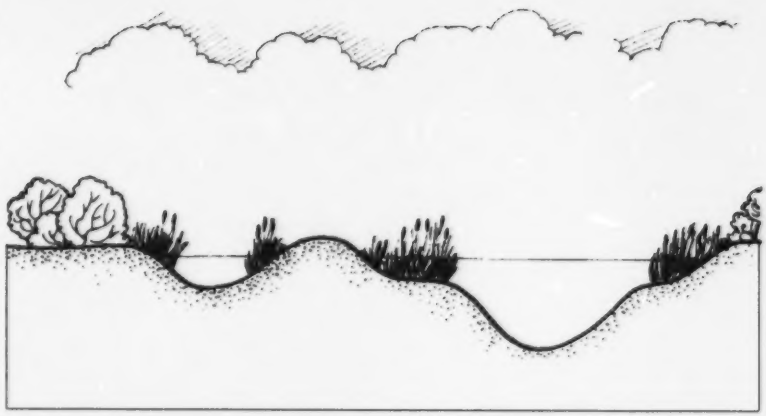


ILLUSTRATION 28, IRREGULAR BOTTOM CONTOURS AND NESTING ISLANDS IN WETLANDS PROVIDE GOOD HABITAT FOR WILDLIFE

A large variety of landforms can be created within a wetland basin during site development and reclamation. During grading and contouring, try to include one of more of the following features (Illustrations 27 & 28):

- Ponds and wetlands should have irregular, rough bottoms. Irregular bottom contours can be created by dumping overburden in an irregular fashion.
- Bottom slopes within the wetland should be contoured like terraces with slopes and flat sections as the depth increases. This provides a wide variety of water depths for establishment of aquatic plants.
- Wetland shorelines should be convoluted, with small bays, and fingers of land protruding into the water. Irregular shorelines such as this provide much more usable habitat for ducks and other wildlife.
- Water depths should range from 0.3 to 1.5 metres within 60 to 80% of the wetland area. At least 20 to 40% of the wetland should be a minimum of 3 metres deep. If parts of the wetland are to be stocked with fish, water should be 5 to 8 metres deep.
- Nesting islands for ducks and geese can be constructed by dumping overburden or waste rock in distinct piles within the wetland.

ILLUSTRATION 27, WETLANDS FOR WILDLIFE SHOULD HAVE AN IRREGULAR SHORELINE, WITH A MIXTURE OF OPEN MEADOWS AND SHRUBS IN THE SURROUNDING AREA

Soil Placement and Water Retention

If you want to develop a lake or pond in an area without an exposed groundwater table, it is essential that the substrate material be impervious to water. When developing the lake or pond basin:

- Any subsoils which contain clays should be stockpiled separately.
- When soils are replaced, the clay subsoil should be compacted over the entire wetland bottom to ensure a water-tight seal. Overburden and topsoil should only be placed down to 1.5 metres below the highwater mark for the wetland. The organic soil will provide a good substrate for establishment of aquatic plants and water tolerant grasses.

Ensuring an Adequate Water Supply

Wetlands generally do not require a continual supply of clean water. In most cases, the water supplies from groundwater and from surface runoff will fulfill the requirements of a wetland project. Adequate water supplies may be provided from:

- Groundwater (if the wetland basin is below the permanent water table); and
- Surface runoff (if the surrounding area is contoured to enhance collection of surface runoff).

Although these two methods are often used to supply a wetland with water, these water sources cannot always be depended on. There are two alternate, and more expensive, methods:

- Those land owners who have river or stream front property may pump water from the river. Note, however, that the cost of such pumping can be high, and that regulatory permits are required from Alberta Environment.
- With permission, water may be diverted from irrigation canals.

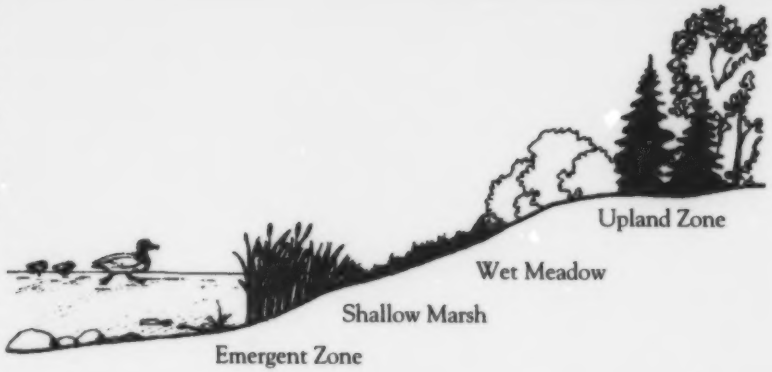


ILLUSTRATION 29, TO ESTABLISH SUCCESSFULLY, SEEDS AND TRANSPLANTS OF WETLAND VEGETATION MUST BE LOCATED IN SITES WITH THE CORRECT WATER DEPTH (SEE TEXT)

As discussed in Chapter 2, you must obtain a water license from Alberta Environment if water is pumped or diverted from a stream or river channel.

Planting and Establishing Wetland Vegetation

There are four recognizable zones of vegetation which are typically found around wetlands. When seeding and planting vegetation, you should try to locate specific types of plants within the appropriate zone (Illustration 29).

The Upland zone extends upward from the highwater mark of the wetland, and will rarely, if ever, experience flooding. Trees, shrubs and groundcovers are usually typical of surrounding natural areas. Where possible, tree and shrub seedlings should be planted upwind of the wetland to provide a windbreak.

The Wet Meadow zone is typically flooded for three or four weeks in the spring. It generally occupies areas with water depths of 0.5 metres or less. Under natural conditions, shrubs such as willows and alders are common. Shrub seedlings and/or stem cuttings of willow, alder, and dwarf birch may be used to establish shrub communities in these wet meadow areas.

The Shallow Marsh zone commonly contains a variety of sedges and water-tolerant grasses, intermixed with a wide variety of broad-leaved forbs. This zone is normally located in areas with water depths of 0.5 metres to 1.0 metre. Sod-forming grasses such as red fescue or flood-tolerant grasses such as reed canarygrass may be broadcast seeded immediately adjacent to the shoreline and will reduce erosion and enhance shoreline features. They also provide excellent nesting cover for waterfowl.

The Emergent zone is typically composed of sedges, rushes and reeds. Water depths in the emergent zone usually range from 0.5 to 2.0 metres. Commercial availability of such plants is limited but these species often establish themselves naturally after a few growing seasons. To speed up the establishment of wetland plants, you can transfer bottom ooze and rootstocks of plants from nearby natural wetlands on your property. Plugs of young aquatic plants or mature root masses may also be transplanted.

Special Wetland Features

Islands

As discussed above, islands can provide safe nesting sites for waterfowl, as well as loafing and feeding sites. Islands also increase the amount of productive shoreline habitat.

Islands are best developed as part of the initial reclamation plan, as they are easier to construct before a wetland is flooded. Front-end loaders and bulldozers may be effectively used to create islands prior to flooding. Islands may be constructed of overburden, rock, or any other relatively stable fill material. The top of the islands should be at least 1 metre above the highwater mark of the wetland. Because vegetation provides important cover for wildlife, the island should be covered with topsoil and revegetated with grasses and a few low shrubs.

Islands should be separated from the shore by permanent water at least 1 to 2 metres deep and 4 to 5 metres wide (Illustrations 30, 31 & 32). While the size of islands can be variable, it is generally more productive to have numerous small islands, than only a few large ones. However, because waterfowl are territorial, islands should be spaced at least 20 to 50 metres apart.

Artificial Nest Structures

Nest platforms, bales, and old tires may be used to provide and enhance nesting sites for waterfowl. Nest structures should be placed in 0.5 metres to 1.0 metre of water and should be located far enough apart so that waterfowl are secluded from each other.

Nest platforms and boxes can be mounted on telephone poles or nearby trees to provide nesting and perch sites for tree nesting species such as blue herons and double-breasted cormorants, or cavity nesters such as wood ducks and buffleheads.

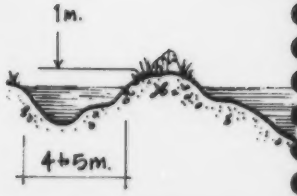


ILLUSTRATION 30, NESTING ISLANDS FOR WATERFOWL MUST BE SEPARATED FROM THE SHORELINE BY PERMANENT WATER (SEE TEXT)

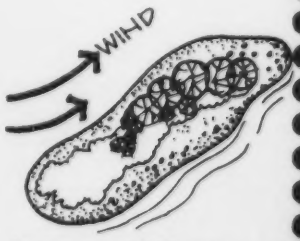


ILLUSTRATION 31, NESTING ISLANDS SHOULD BE 4 TO 5 METRES WIDE, WITH THE LONG AXIS PARALLEL TO THE PREVAILING WIND

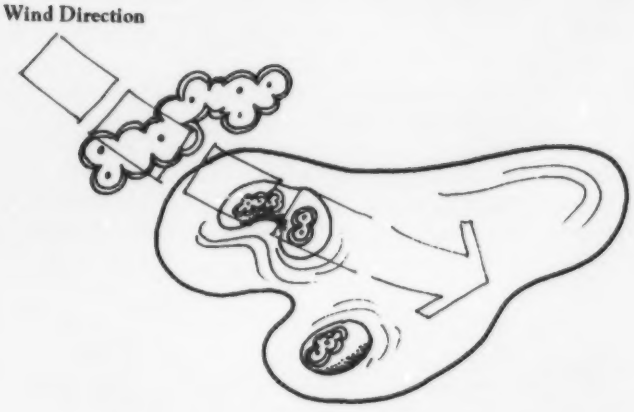


ILLUSTRATION 32, NESTING ISLANDS SHOULD BE LOCATED CLOSE TO THE WINDWARD SIDE OF THE POND TO MINIMIZE WAVE EROSION

- Nesting platforms should be 0.5 to 1.0 square metre in size and should be lined with wire mesh. Platforms should be mounted in old trees or on telephone poles, at least 3 to 8 metres above the water (Illustration 26).
- Wire platforms for ground nesters such as the Canada goose should be placed in at least 0.3 metres of water and the level of the nest platform should be at least 1.0 metre above highwater level (Illustration 26).
- Wire nest baskets, cylinders, cones, and wooden nest boxes for cavity nesting ducks should be placed a minimum of 3 metres above ground level on trees or poles close to the water's edge, or in 0.5 to 1.0 metre of water (Illustration 26).
- Round hay bales can provide excellent nesting sites for Canada geese and ducks (Illustration 33). Flax bales last longest, and should be wrapped with hog wire to keep the bale together. Bales should be placed 10 metres or more offshore in water no deeper than 1.0 metre. A minimum of 1 ha of wetland is required for each nesting bale. Bales can be easily placed in a wetland by dropping the bale through a hole in the ice during winter.

ILLUSTRATION 33, ROUND HAY BALES CAN BE USED TO PROVIDE EXCELLENT NESTING SITES FOR CANADA GEESE

Several excellent publications on nesting structures for waterfowl are available through your local office of the Alberta Fish and Wildlife Division.

Management of Wetland Habitat

Wetlands, like upland areas, may require fencing during the first several growing seasons to allow vegetation establishment. As wetland vegetation tends to die out when continuously flooded, the wetland should be partially drained every 3 to 10 years to allow re-establishment of aquatic plants. Natural cycles of drought and wet spells will sometimes provide adequate changes in water levels. However, you may want to install an outlet with a controllable weir on your wetland to permit easier management of water levels.

OTHER SOURCES OF INFORMATION

For additional information on reclaiming wildlife habitat, write or phone:

Habitat Branch,
Alberta Fish and Wildlife Division,
2nd Floor, Bramalea Building,
9920 - 108th Street,
Edmonton, Alberta
T5K 2M4
Phone: (403) 427-9506

Land Reclamation Division,
Alberta Environment,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Within Alberta, you can call these government agencies toll free through the R.I.T.E. Telephone Network. See Chapter 10 for a listing of the R.I.T.E. Telephone Number in your area.

Additional assistance on reclamation of wildlife habitat can be obtained from:

Ducks Unlimited,
#302, 10335 - 172 Street,
Edmonton, Alberta
T5S 1K9
Phone: (403) 489-2002

Wildlife Habitat Canada,
#301, 1704 Carling Avenue,
Ottawa, Ontario
K2A 1C7
Phone: (403) 722-2090

Books and Reports

1. *Habitat Development Fact Sheets*. Available through the regional offices of the Alberta Fish and Wildlife Division.

2. *Wildlife Habitat: A Handbook for Canada's Prairies and Parklands*. Available from Western and Northern Region, Canadian Wildlife Service. Environment Canada, Edmonton, Alberta.

3. *Methods for Reclamation of Wildlife Habitat in the Canadian Prairie Provinces*. Available from Western and Northern Region, Canadian Wildlife Service. Environment Canada, Edmonton, Alberta.

RECLAIMING FISH HABITAT

Fish habitat may be a viable end use for your operation if adequate water supplies are present. Fish habitat projects are often compatible with other end uses, particularly in combination with the development of wetland habitat.

If you have selected fish habitat as the end land use for your pit or quarry, or as a secondary use to include with other land uses, this chapter provides specific information on issues that may affect your choice of fisheries habitat:

- Important considerations in reclaiming fish habitat on your site:
  - land use zoning,
  - water availability,
  - water quality,
  - shape, size and depth of your pit or quarry.
  - pit slopes,
  - type of fish, and
  - progressive reclamation and development.
- Methods for reclamation:
  - grading and contouring,
  - creating suitable waterbodies for fish,
  - spawning,
  - ensuring an adequate water supply,
  - maintaining water quality, and
  - providing adequate food.

IMPORTANT CONSIDERATIONS IN RECLAIMING FISH HABITAT ON YOUR SITE

Land Use Zoning

Before planning and developing your site, be sure to review local ordinances and current and proposed Land Use Zoning regulations. These regulations, established by the Regional Planning District offices and the Provincial Government, will allow you to determine if development of fish habitat will be allowed on your site and what types of restrictions may apply.

Water Availability

If you are going to make a fish pond, you will require a permanent supply of clean, fresh, water. Ponds may sometimes form in pits or quarries if local runoff is sufficient and the pond bottom is well sealed. Ponds may also be created when pits are excavated below the groundwater table. In many cases, however, you will need to obtain additional water to maintain water quality, as well as water levels. Water can be pumped from adjacent water courses or waterbodies or under the Water Resources Act diverted from local streams if licensed by Alberta Environment. On public land, you will need to contact Alberta Forestry, Lands and Wildlife to obtain access.

Water Quality

Water quality requirements will depend on the type of fish that will be raised, and the likely use of these fish. If you plan to use the pond for a "put and take" fishery, then water quality is very important. Poor quality water will retard fish growth and affect taste.

Shape, Size and Depth of Your Pit or Quarry

The shape of a pit is of little concern for fish use. However, if your pit has an irregular shoreline, it will provide a greater variety of habitats for fish. As discussed in Chapter 6, irregular shorelines also benefit wetland wildlife.

The size of your pit is also of little consequence for fish production, except in determining the number of fishermen that may use your pond.

- Ponds up to 2 hectares in size can serve one or two fishermen, or provide a family trout pond.
- Ponds for public use must be much larger to accommodate a full season of fishing.

The depth of your pit is perhaps the most important, limiting characteristic. As shallow, surface pits are likely to fill in with aquatic weeds and will not support fish, they are best developed as wetland habitat. Good quality ponds for rearing and overwintering of fish require one or more water zones at least 5 to 8 metres deep.

Pit Slopes

Steep pit slopes can provide excellent offshore angling opportunities because of the depth and shade which they provide near the shoreline. However, steep pit slopes should be retained only if they are stable rock cliffs. Loose soil and gravel highwalls are likely to undercut or slump, and are a safety hazard.

Type of Fish

A number of sport fish thrive in Alberta. A common sport fish, the northern pike is found in many Alberta lakes and ponds (Photo 27). The pike will thrive in warm, shallow waters and will also reproduce in such water.

The rainbow trout is generally more sought after for stocking of lakes and ponds. The rainbow trout will give you a spectacular fight when hooked. The trout thrives in cool waters. Because they require small gravels and flowing water to spawn, they generally do not reproduce in reclaimed ponds. Rainbow trout are commercially available for stocking from many fish hatcheries in the province.

Certain types of fish cannot share the same ponds. While rainbow trout and brown trout are compatible, pike and trout are not compatible, as a mature pike will feed on the trout.

PHOTO 27, RAINBOW TROUT AND PIKE ARE COMMON SPORT FISH IN ALBERTA THAT ARE SUITABLE FOR STOCKING IN RECLAIMED PONDS

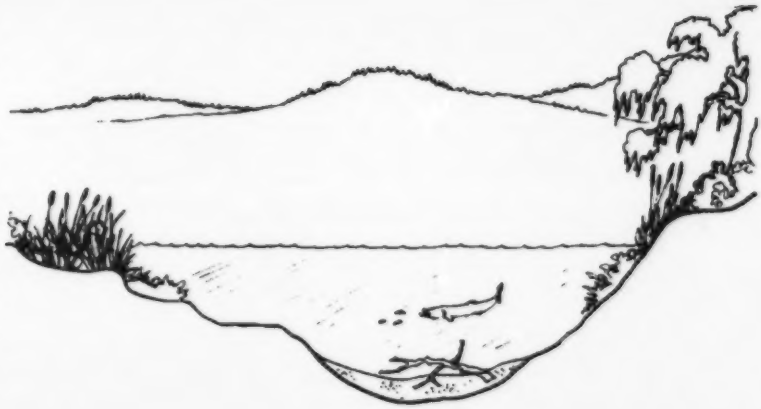


ILLUSTRATION 34, FISH PONDS SHOULD BE AT LEAST 5 TO 8 METRES DEEP. TERRACED BOTTOM CONTOURS PROVIDE DIVERSE HABITAT FOR FISH AND THEIR PREY

Progressive Reclamation and Development

Progressive reclamation and development can be put to use in preparing the bed of your pit. While equipment is available, numerous landforms can be created to enhance underwater habitat and fishing conditions. The requirement of clean water for a fisheries operation generally precludes the flooding of one section of the extraction facility while work is ongoing in other sections, unless the sections are separate excavations and the water from one does not drain into the other. If a vegetation cover is established it will better prepare the bottom of the pit for eventual flooding.

METHODS FOR RECLAMATION

Grading and Contouring

During the operating period of your pit, overburden and waste materials can be redeposited and graded into diverse landforms above and below the waterline.

Where recreational angling is desired, the banks should be graded to a slope of 3:1, whenever possible. This will minimize weed growth along the shore, and provide better access for casting and landing fish. To provide adequate cover for fish, you can build artificial reefs and shoals offshore (see below) where they will not interfere with shoreline angling.

Fish ponds should also include areas with shallower slopes to provide spawning and nursery areas for fish. These shallow areas will also benefit waterfowl. Construction of terraced benches with shallow slopes (Illustration 34) create a variety of water depths. This diversity of water depths provides suitable areas for different types and heights of aquatic plants that provide shade and hiding cover for juvenile and adult fish.

Creating Suitable Waterbodies for Fish

Depth

Your fish pond will be most productive when a variety of water depths are provided. As a general rule of thumb,

- Approximately one third of the pond surface area should have minimum water depths of 5 to 8 metres. This provides overwintering areas for fish.
- Approximately one quarter of your pond should be shallow water with depths of 0.5 to 1.5 metres.
- The remaining areas should have variable depths between these two extremes (Illustration 34).

Cover

If the bottom of your pit has already been smoothly graded, or if few opportunities exist to create irregular bottom contours, you should consider adding structures that will provide underwater cover for fish. These structures often provide good habitat for fish prey. Prior to flooding of the pond, you can construct a number of artificial "reefs" or shoals using materials such as:

- Brush piles,
- Anchored, submerged tree crowns,
- Bundles of old tires, and
- Loose piles of rock, concrete blocks, and broken tiles (Illustrations 35 & 36).

These artificial reefs can also be hauled onto the ice during winter, and allowed to sink the following spring.

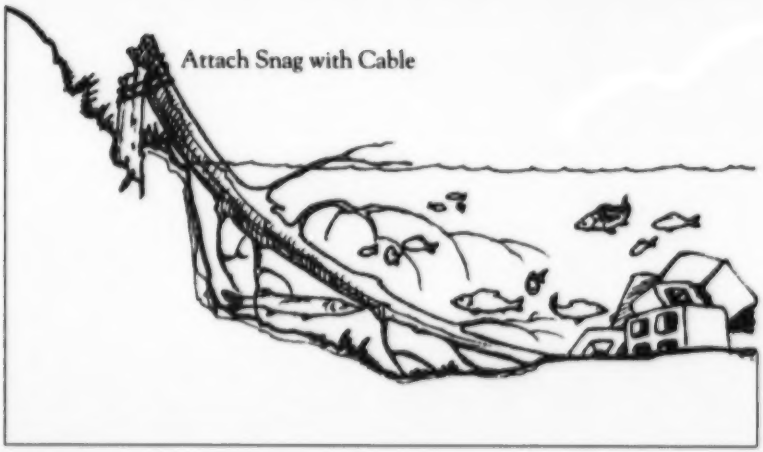


ILLUSTRATION 36, SNAGS AND WASTE CONCRETE CAN PROVIDE PROTECTIVE COVER FOR FISH

In shallow bays and other nearshore areas (up to 2 metres in depth), rooted aquatic plants will provide protective cover for brook trout, rainbow trout, pike, and smaller fish, as well as habitat for many other aquatic organisms. Although a variety of aquatic plants will eventually establish themselves, the process can be accelerated by transplanting plugs of aquatic plants or mats of floating plants from adjacent wetlands. Plugs of cattails, bulrush, and sedges can be dug by hand or with a backhoe. Just prior to flooding, these plugs should be firmly planted in the bottom substrate and anchored with a rock.

Shoreline Vegetation

Shade is important for some fish species, such as brook trout. By planting trees, brush, and other vegetation along or overhanging the banks of your pond, you can provide shade cover, and greatly improve fish production in your pond (Illustration 34). This is particularly valuable if there are deep pools within the shaded area. Insects in the shoreline vegetation are a good source of food for fish, as they often drop on, or fly over, the surface of the water.

Shrub seedlings and stem cuttings of willow, alder, and dwarf birch are useful in establishing shrub communities along the shoreline of fish ponds.

One problem with planting trees along your pond is that the leaves will fall into the pond in autumn. Leaves which fall into the pond use up a lot of the oxygen in the water when they decay. If too much dissolved oxygen is taken from the pond, winter kill of fish can occur. If your pond does not have a fresh water supply, only a small number of deciduous (broadleaf) trees should be planted along the shoreline.

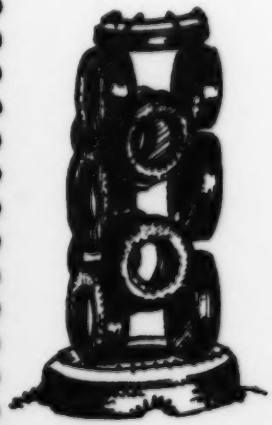


ILLUSTRATION 35, OLD TIRES CAN BE USED TO CREATE REEFS AND SHOALS FOR FISH

Spawning

Rainbow and brook trout are stream spawners which require fine gravels and inflowing streams. These fish bury their eggs in select parts of the stream, usually in riffles at the lower boundary of pools where there are fine, clean gravels, and no large rocks. These areas, which are low in sediments but high in gravels, provide good hiding places. Sites without these characteristics will not support natural reproduction and trout stocks will need to be maintained on a put and take basis.

Spawning habitat for trout must have two basic characteristics:

- Fine gravels in which the fish can lay their eggs; and
- Moving water to carry oxygen to the eggs, and remove wastes and silt from around the eggs.

This habitat is not commonly available in reclaimed ponds. However, it may occur upstream or downstream along inlet and outlet channels to your pond.

PHOTO 28, EXPOSED WATER TABLES DURING EXCAVATION CAN PROVIDE HIGH QUALITY WATER FOR FISH HABITAT

Ensuring an Adequate Water Supply

Your pond should preferably have a supply of fresh water throughout most of the open water period to maintain water quality, and to replace water that is lost through evaporation and seepage. The best situation is a pond with a continual flow of fresh water through an inlet and outlet channel.

Potential supplies of fresh water for your pond include:

- Exposed groundwater tables during excavation below the permanent water table often provide high quality water conditions, and can be developed as good fish habitat (Photo 28).
- High quality groundwater reserves may be accessible from deep wells. However, the mineral content of some ground water may make it unsuitable for fish use.
- Use of irrigation water may be allowed in some irrigation districts. To use irrigation water, you will need to obtain a user permit. You will also need to build a pipeline or lateral ditch to your pond. As irrigation canals may contain undesirable fish such as suckers, the inlet should be screened. Irrigation water may also contain fertilizers, pesticides, and herbicides that are detrimental to fish. As a result, this type of development requires careful review and input from government agencies.
- Water from adjacent rivers and streams can be pumped or diverted to your project.

Regardless of the water source, pumping of water into a pond can be costly. All of these options require authorization and permitting by Alberta Environment or Alberta Forestry, Lands and Wildlife.

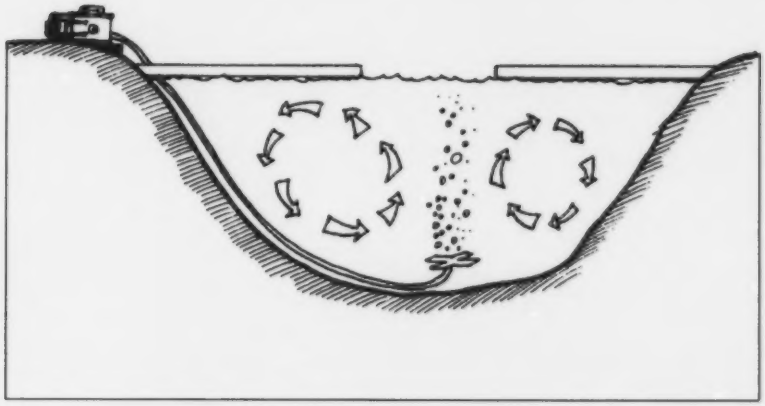


ILLUSTRATION 37, YOU MAY NEED TO AERATE YOUR FISH POND TO SUCCESSFULLY OVERWINTER FISH

Maintaining Water Quality

Water quality is usually best when a fresh supply of clean, clear water is available to the impoundment. There are a number of situations, however, that can seriously degrade water quality, such as:

- Fertilizer-rich runoff from farm fields,
- Leaching of nutrients from cattle yards and feedlots, and
- Overspraying of herbicides and insecticides (Photos 29 & 30).

Surface drainage from these types of areas should be directed away from the drainage basin for your pond. You should also avoid use of fertilizers, insecticides and herbicides in the vicinity of your pond.

An additional concern is the lack of oxygen for fish over winter. Because the surface of your pond is sealed off from air during the winter, oxygen reserves in the water may be depleted. If oxygen levels become too low, fish kills will occur. Two possible solutions are:

- Construction of one or more deep water zones (5 to 8 metres or more) to provide adequate supplies of oxygen for overwintering fish. Note, however, that under-ice conditions must allow mixing of water to maintain adequate oxygen for fish.
- Aeration of the water using wind or motor driven pumps. By injecting air bubbles into the deeper areas of the pond, oxygen levels can be increased through direct aeration, mixing of the water, and by creating open water areas in the ice (Illustration 37).

PHOTO 29, INCORRECT APPLICATION OF HERBICIDES AND PESTICIDES CAN BE A LOCAL SOURCE OF WATER POLLUTION.

Providing Adequate Food

Adequate food for fish is generally provided if external surface water sources are used for water maintenance. However, if your pond is maintained by cold groundwater sources, there may be inadequate food for fish, particularly during the first 3 to 5 years after reclamation.

Once a pond is established, aquatic plants, bottom substrates and artificial "reefs" can provide habitats for small aquatic animals and plants that are important fish foods. As noted above, trees and shrubs along the pond shoreline can provide a good supply of insects for fish.

In general, both the pike and trout families feed on aquatic organisms which are typically present in Alberta waters. Pike primarily feed on aquatic organisms such as snails, minnows, and small fish. Larger pike will also eat young muskrats and ducklings. Members of the trout family feed primarily on insects, leeches, clams, snails, and occasionally on small fish.

PHOTO 30, CATTLE MANURE CAN BE A LOCAL SOURCE OF WATER POLLUTION

OTHER SOURCES OF INFORMATION

For additional information on reclaiming fish habitat, write or phone:

Habitat Branch,
Alberta Fish and Wildlife Division,
2nd Floor, Bramalea Building,
9920 - 108th Street,
Edmonton, Alberta
T5K 2M4
Phone: (403) 427-9506

Land Reclamation Division,
Alberta Environment,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Within Alberta, you can call these government agencies toll free through the R.I.T.E. Telephone Network. See Chapter 10 for a listing of the R.I.T.E. Telephone Number in your area.

Additional assistance on reclamation of fish habitat can be obtained from:

Trout Unlimited,
P.O. Box 627, Station "D",
Calgary, Alberta
T2P 2C8
Phone: (403) 221-8360

Books and Reports

1. *Habitat Development Fact Sheets*. Available through the regional offices of the Alberta Fish and Wildlife Division.

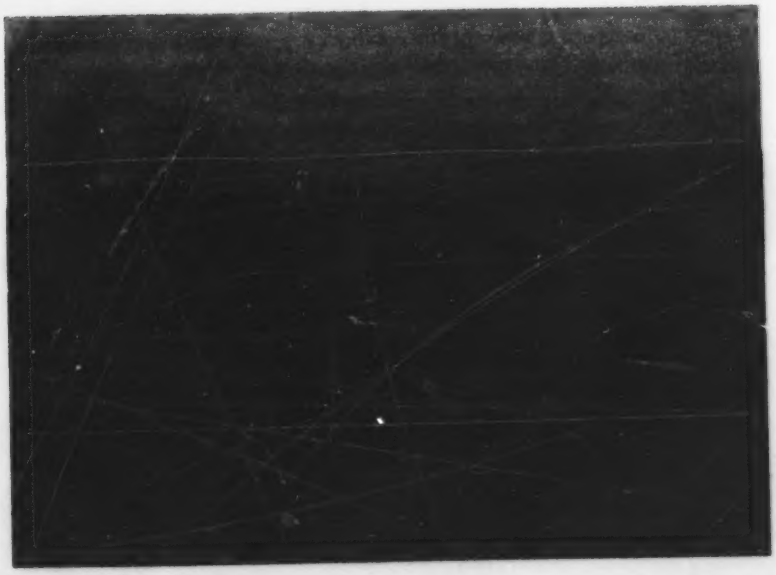
2. *Wildlife Habitat: A Handbook for Canada's Prairies and Parklands*. Available from Western and Northern Region, Canadian Wildlife Service. Environment Canada, Edmonton, Alberta.

3. *Methods for Reclamation of Wildlife Habitat in the Canadian Prairie Provinces*. Available from Western and Northern Region, Canadian Wildlife Service. Environment Canada, Edmonton, Alberta.

RECLAIMING LAND FOR RECREATION

If you have selected recreation as the end land use for your pit or quarry, or as a secondary use to include with other land uses, this chapter provides specific information on issues that may affect your choice of recreation developments:

- Important considerations in reclaiming your site for recreation:
  - adjacent land uses,
  - land use zoning,
  - types of recreational use,
  - design stages for your recreation area, and
  - progressive reclamation and development.
- Methods for reclamation:
  - grading and contouring,
  - site drainage,
  - creation of waterbodies,
  - replanting trees, shrubs and groundcovers,
  - providing public facilities.



Recreation encompasses many things. It can include a wide range of different activities from physical challenges to solitude, social gatherings, and wilderness experiences. Recreation can generally be defined as any activity that takes place in the absence of other demands on our time, where there are no commitments or products to produce.

To be successful, reclamation of a pit or quarry for recreation must address five objectives:

- *Uniqueness:* Recreational developments should be based on natural and cultural themes that are important in the local area.
- *Environmental Responsibility:* Recreational opportunities should be compatible with the site conditions, surrounding landforms and adjacent land uses, while also meeting user demands.
- *Balanced Integration:* The level of site development must be compatible with the capacity of the reclaimed area to support recreation.
- *Economic Viability:* Recreational developments must be economic to construct, maintain, and operate.
- *Flexibility:* The framework for development and final reclamation of the pit or quarry must be able to accommodate ongoing changes in adjacent land uses and the environment.

As with all land uses, effective planning for a recreational end use should be part of the design and operational phases for your pit or quarry.

IMPORTANT CONSIDERATIONS IN RECLAIMING YOUR SITE FOR RECREATION

Reclamation of a pit or quarry for recreational purposes can be a complex process requiring input on public safety, regional and local recreational needs, facility planning and landscaping, aesthetics and access. To assist you in the planning of multiple use or large recreational facilities, you will likely need to retain the services of a landscape architect or a recreational planner. General recommendations for reclamation of recreational lands are provided in the remainder of this chapter.

Protecting resources and retaining natural scenic beauty are essential to providing quality natural recreation experiences. Because of this, you should identify the important landscape features within and adjacent to your proposed pit or quarry. The abundance and variety of landscape elements which exist on and adjacent to the site need to be recorded. Based on these features, you can then establish objectives for retaining and protecting visual qualities. Once you have identified the types of visual elements that will be kept or developed in and around your development, you can then select the recreational activities that best suit these conditions, or use natural elements to highlight desired recreational activities.

Adjacent Land Use

To determine if your pit or quarry has potential for recreation, it is first necessary to consider the types of land uses that occur around your site (see Chapter 3). Establishing current and proposed (if possible) land uses will assist you in determining the most suitable type of recreation facility for your reclamation area. For example, if there are few local opportunities for lake or stream fishing the development of a recreational put-and-take fishing pond could be a great attraction.

In addition to adjacent land uses, you must also consider the proximity of your site to other recreation facilities, the services these other sites offer, and your potential to attract recreation area users. Other important considerations include:

- the location of your site relative to tourist travel routes;
- the numbers and origin of potential users (urban versus rural users);
- proximity to recreational waterbodies;
- available utility services;
- health and development regulations;
- access to the site; and
- recreational trends.

Land Use Zoning

Before planning and developing your site, be sure to review local development controls and current and proposed Land Use regulations. These regulations, established by local, regional and provincial planning authorities will allow you to determine if a recreation development will be allowed on your site and what types of recreation will be permitted.

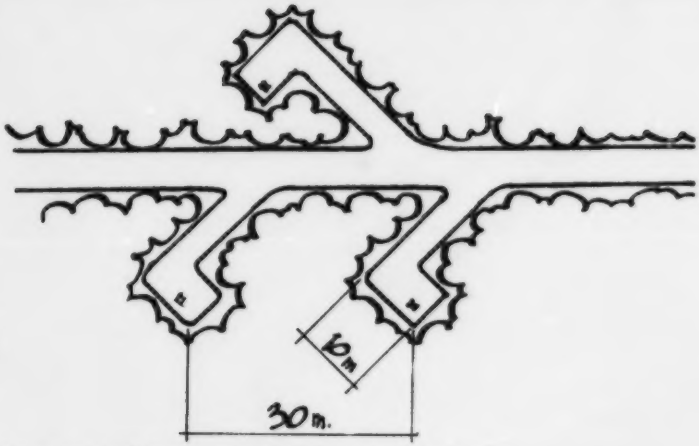


ILLUSTRATION 38, TYPICAL LAYOUT FOR BACK-IN SPUR CAMPSITES

Types of Recreational Use

The type of recreational use you provide will depend on two major factors: the size of your reclamation area, and market demands.

The amount of area available is important in determining the potential for different recreational activities. For example, campgrounds will require the greatest amount of area. Back-in spur campsites on loop roads are the most common arrangement. Sites are generally spaced 30 metres on centre and are 10 metres wide (Illustration 38). Picnic and other types of day use areas vary in size depending on the type of facility. In all cases, adequate parking and basic user comfort facilities must be provided.

Market demand will provide an indication as to what type of recreation facilities are required. These may vary from intensely developed commercial theme parks to convenient roadside rest areas. To determine the best type of recreational use for your site, first determine the overall area and the quality of your site's main features. Important features include the types and location of:

- landforms such as rolling hills, flat areas, and bluffs,
- waterforms such as ponds, wetlands and streams,
- forested and open vegetation communities, and
- historic and prehistoric cultural sites

If you are uncertain of your site's potential, government agencies such as Alberta Tourism, Alberta Forestry, Lands and Wildlife, and Alberta Recreation and Parks can assist you in identifying potential uses, as well as important local and regional needs. You should then assess your potential to service the desired market. For large reclamation areas, you may want to retain a consultant to assist with the determination of the most appropriate recreational activities to provide. On public lands, Alberta Forestry, Lands and Wildlife will often stipulate the preferred end use.

Design Stages for Your Recreational Area

Once you have decided to reclaim your pit or quarry to provide recreational facilities, you should design an overall site plan. As noted above, you should develop your site plan along with the site extraction plans in order to maximize the advantages of both the site resources and the planned recreation activity. The design of your site plan should involve four stages:

- programming,
- planning,
- concept design, and
- detailed design.

Programming

During the programming stage, you will need to consider regional and local markets for recreation. On the basis of your review of market demands, you can develop objectives that outline the facilities you want to provide, establish a development schedule, and set your overall budget. Seasonal considerations should be included in your objectives. Summer, for example, may include activities such as picnicing, hiking, all terrain vehicle usage, camping, swimming, fishing, archery, shooting, and wildlife observation. Winter activities may include cross country skiing, snowmobiling, skating, camping, and ice fishing.

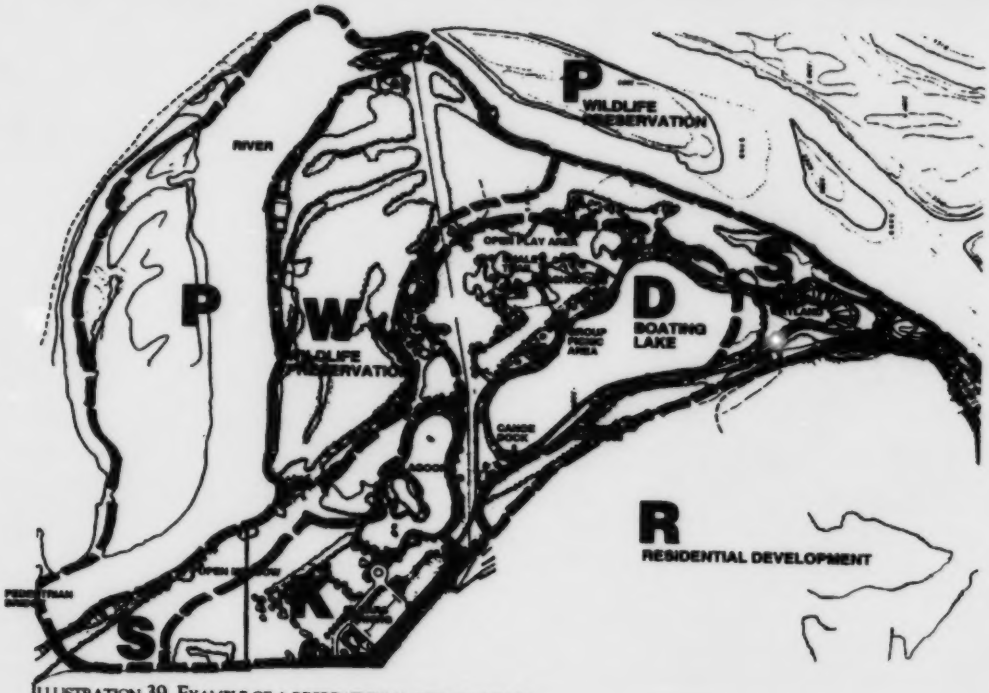


ILLUSTRATION 39, EXAMPLE OF A RECREATIONAL SITE ZONE PLAN

Planning

During the planning stage, you will need to determine the specific areas and location requirements for each of the recreational uses that you have proposed. You should also consider how each of these uses will relate to each other in terms of space, location, season of use and type of activities. These uses should then be illustrated on a site zoning plan (Illustration 39). The zoning plan should also identify sensitive environmental areas such as erosion-prone soils and slopes, plant communities, waterbodies, and water courses. Remember to consider the local development regulations and guidelines as part of this planning process.

Concept Design

The concept design is similar to a zoning plan, but provides more detail on the proposed types of facilities for each recreational use (Illustration 40). The concept design illustrates the different types of uses, and sets out the general dimensions and relationships between each of the recreation facilities to be provided. Your concept plan should be of sufficient detail to allow development permit applications to be made. For larger recreational projects such as golf courses, engineering studies are usually required for site drainage and facility development. As the concept design and engineering studies are completed, the project schedule and budget should also be refined.

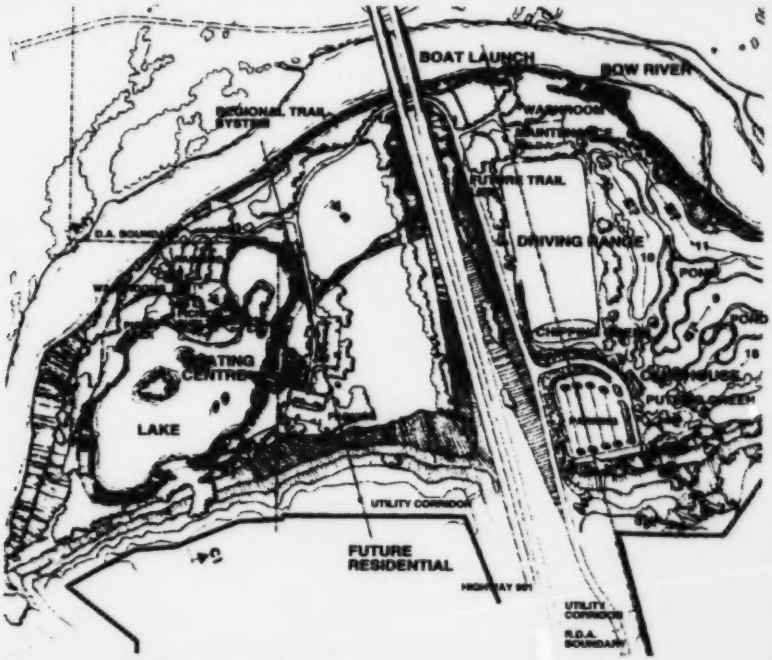


ILLUSTRATION 40, EXAMPLE OF A RECREATIONAL CONCEPT DESIGN

Detailed Design

The detailed design is the final step in the design process, and includes the preparation of working drawings and specifications that are suitable to permit construction (Illustration 41). Your detailed design should set out the specific quality and quantity requirements for your recreational project, such as:

- final landforms,
- utility locations,
- roads and parking,
- site developments including buildings,
- landscaping, and
- maintenance and operations.

Progressive Reclamation and Development

As with most land uses, progressive reclamation and development of your pit or quarry is strongly recommended. For recreational land uses, progressive development and reclamation will permit you to sequentially develop different areas for specific recreational uses. By minimizing the actively disturbed area of the pit, progressive development and reclamation also limits the visual impacts of extraction on existing and proposed recreational uses.

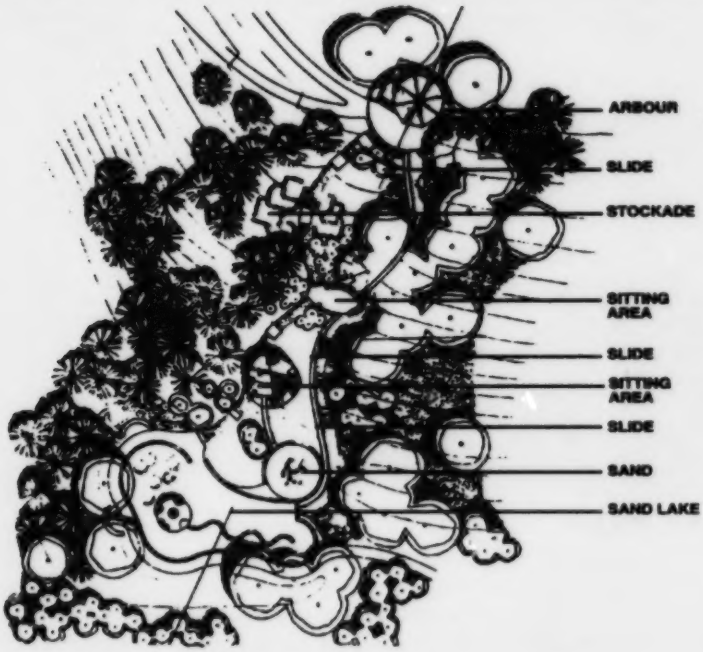


ILLUSTRATION 41, EXAMPLE OF A DETAILED DESIGN FOR RECREATION FACILITIES

METHODS FOR RECLAMATION

Grading and Contouring

For recreational end uses, grading and contouring of a pit or quarry is often necessary to:

- provide level areas for activities such as sports fields,
- construct roads and pathways for vehicle and foot access,
- solve site development problems such as poor drainage, or high wind exposure, and
- create special features such as ponds or rolling landforms.

Landforms that are preferred or required for your proposed recreational uses can be created by cut and fill, excavation, and use of suitable waste materials or offsite fill.

Due to the potential for settling, it is important that the subsoil be well compacted within and adjacent to any proposed facility or sports field.

PHOTO 31, A RECREATIONAL PO
IN A RECLAIMED SITE

Site Drainage

As depressional areas are usually created during the development of pits and quarries, it is important that you develop adequate site drainage to provide well-drained areas for land-related recreational activities. In contrast, you may want to direct local surface runoff to provide water for tree and shrub plantings, or wetlands and ponds. Basic approaches to site drainage are discussed in Chapter 2.

Creation of Waterbodies

During the grading and contouring of your site, it is often possible to direct surface runoff towards specific depressions or low areas to create a pond or wetland. Where your pit or quarry has exposed the groundwater table, water levels in these areas will often be maintained by groundwater sources. However, if ponds and wetlands are to be valuable assets for your recreational use, the area surrounding the waterbody should be shaped to provide a natural-looking basin (Photo 31). Users shouldn't feel like they're in a hole. A recreational consultant or landscape architect should be contacted for advice on construction and maintenance of recreational lakes and ponds.

Replanting Trees, Shrubs and Groundcovers

If all or part of your pit operation was cleared out of an existing forest, the trees along the forest edge are often prone to blow down until they establish a hardier root system. Trees which have blown down should only be removed if they are unsightly or present a hazard to the recreational use of the area.

Groundcovers (grasses and forbs) should be established as early as possible in the reclamation process in order to reduce erosion, control dust, and improve the quality of the soil. In the short term, you may want to plant forage crops to control erosion and reduce impacts on adjoining properties (a

PHOTO 32, YOU MAY NEED TO PROVIDE A VARIETY OF FACILITIES FOR RECREATIONAL USE

good neighbour policy). In the long-term, you will want to select groundcovers that best suit the proposed recreational use. For organized activities such as playing fields and picnic sites, you will want to select grasses that can withstand heavy foot traffic. In nature-oriented recreational areas, you may want to plant palatable groundcovers to entice wildlife (see Chapter 6).

For many recreational uses, you will want to plant trees and shrubs to:

- separate different recreational activities, such as playing fields and picnic sites, from one another;
- define specific areas such as individual campsites or picnic sites;
- screen natural areas from areas for organized activities; and
- improve the scenic quality of your site.

You should only plant trees and shrubs that are proven to be hardy for your region. As a rule of thumb, the most suitable types of trees and shrubs will be those that existed on your site prior to development, or that exist in adjacent areas.

Providing Public Facilities

Depending on the type of recreational activities that you select, and the number and type of users, you may need to provide basic facilities such as shelters, toilets (pit privies/ flush toilets), drinking water, garbage disposal and parking (Photo 32). Additional facilities such as picnic tables, fire pits, trails and the development of site amenities may also be required, and can greatly improve the recreational values of your site. In some locations such as urban fringes, interpretive signs can be posted describing the development and reclamation process for your pit.

OTHER SOURCES OF INFORMATION

For additional information on reclaiming land for recreation, write or phone:

Alberta Recreation and Parks,
Standard Life Centre,
10405 Jasper Avenue,
Edmonton, Alberta
T5J 3N4
Phone: (403) 427-2008

Alberta Tourism,
10155 - 102nd Street,
Edmonton, Alberta
T5J 4L4
Phone: (403) 427-4321

Forest Land Use Branch,
Alberta Forest Service,
6th Floor, Bramalea Building,
9920 - 108th Street,
Edmonton, Alberta
T5K 2M4
Phone: (403) 427-3582

Land Management Branch,
Alberta Public Lands Division,
4th Floor, South Petroleum Plaza,
9915 - 108th Street,
Edmonton, Alberta
T5K 2C9
Phone: (403) 427-6597

Land Reclamation Division,
Alberta Environment,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Within Alberta, you can call these government agencies toll free through the R.I.T.E. Telephone Network. See Chapter 10 for a listing of the R.I.T.E. Telephone Number in your area.

Additional information on reclaiming land for recreation may be available from:

The Alberta Association of Landscape Architects,
#370, 4445 - Calgary Trail South
Edmonton, Alberta
T6H 5R7
Phone: (403) 435-9902

RECLAIMING FOR RESIDENTIAL AND INDUSTRIAL USES

If you have selected a residential and industrial land use for your pit or quarry, this chapter provides specific information on issues that may affect your choice of residential or industrial development:

- Important considerations in reclaiming your site for residential and industrial uses:
  - municipal bylaws,
  - land use zoning,
  - adjacent land uses,
  - demand for development sites,
  - access,
  - keeping your development concepts flexible, and
  - progressive reclamation and development.
- Situations to avoid:
  - shallow groundwater,
  - flooding potential,
  - poor foundation conditions, and
  - undevelopable areas,
- Methods for reclamation:
  - backfilling,
  - grading and contouring,
  - development of slopes,
  - site drainage,
  - replacing overburden and topsoil, and
  - re-establishing plant cover.

IMPORTANT CONSIDERATIONS IN RECLAIMING YOUR SITE FOR RESIDENTIAL AND INDUSTRIAL USES

Municipal By-Laws

Development of pits and quarries for residential or industrial use must conform to provincial and municipal zoning regulations. Under the Alberta Planning Act, municipalities and municipal districts are required to:

- prepare general, regional, and local plans to guide land use planning, and
- specify guidelines for land subdivision (which must, in turn, conform to existing general, regional or local plans).

As a result, your municipality or district must approve the development of a sand and gravel operation (Chapter 2). They must also ensure the proposed end land use is compatible with land use and zoning regulations. If you have decided to develop your pit for a residential or industrial use, you should maintain close contact with municipal staff throughout the planning, development, and reclamation phases of your operation.

Land Use Zoning

Zoning by-laws are enacted by the municipality to ensure that development proceeds in compliance with the general, regional and local plans. Around the cities of Calgary and Edmonton, by-laws also apply to restricted development areas, and transportation and utility corridors. These areas have been established to control development and dedicate rights of way for major roads and utilities.

Before planning and developing your site, be sure to review local ordinances and current and proposed Land Use Zoning regulations. These regulations, established by the Regional Planning District offices, the Provincial Government, and municipalities, will allow you to determine if residential and/or industrial land uses will be permitted on your site.

Adjacent Land Use

Land use zoning will normally ensure that your proposed residential or industrial land use is compatible with adjacent land uses. However, if your pit or quarry is close to a major urban area, land use may be in transition, tending to change over time from farming or range lands to residential and industrial uses. A high density residential or industrial land use may be appropriate in this case. On the other hand, only a low density residential development (such as acreages) might be compatible with other rural land uses. Industrial and high density residential developments would not likely be acceptable.

Demand for Development Sites

Assuming that you can obtain zoning approval for your residential or industrial land use, you should ensure there is or will be a demand for your proposed use. Demand will often depend on the location of the property relative to city centres and transportation routes. Your municipality should be able to assist you in determining the demand for your proposed residential or industrial use. On public lands, Alberta Forestry, Lands and Wildlife will often stipulate the preferred land use.

Access

Road access to your site is a very important factor in assessing the suitability of your site for either residential or industrial development. If your operation is close to a population centre, a network of access roads and utilities may already be in place or available close by. Development of your site may therefore proceed without major costs for access improvements and infrastructure. In rural areas, however, development costs could be prohibitive if your site is well removed from adequate road access or utility connections.

Keeping Your Development Concepts Flexible

As discussed in Chapter 2, your development concept and plan should be established *before* site preparation begins. However, if your operation will involve a large area and/or continue for more than ten years, it is possible that municipal by-laws or land use zoning will change. Local and regional demand for a specific type of residential or industrial development site may also change.

To be able to respond to these uncertainties, your development concept should remain flexible. This will allow you to make allowances for changes and modifications in your development and reclamation plans as required.

Progressive Reclamation and Development

As with most land uses for pits and quarries, progressive reclamation and development will directly benefit residential and industrial uses by permitting you to develop some areas of your site operation well in advance of the final abandonment of your operation. Progressive reclamation and development can also save you money by minimizing multiple handling of topsoil, overburden and aggregate, and making best use of heavy equipment when it is easily available.

SITUATIONS TO AVOID

There are a number of situations to be avoided in developing a pit or quarry for residential and industrial uses, including:

Shallow Groundwater

Groundwater is a concern for residential and industrial developments in areas where the seasonal high groundwater table can rise to within 1.5 metres or less below the ground surface. You can generally avoid this problem by raising development site grades. Otherwise, you will need to consider measures to protect basements and other below-grade structures from seepage.

Flooding Potential

Because gravel and sand pits are frequently located adjacent to river and stream channels, you should ensure that the final grade of your residential or industrial area will be above the level of major floods (i.e., the 1:100 year flood). Development in such areas may also be controlled by land use zoning and provincial regulations.

Poor Foundation Conditions

In many instances, the soils underlying sand and gravel deposits will provide good foundation conditions for residential and industrial structures. However, if you backfill all or part of your site with imported material, you may encounter ground settlement problems. If you are in doubt as to the adequacy of the foundation conditions in your proposed site, it is wise to consult a qualified geotechnical engineer.

Undevelopable Areas

When you are preparing a development concept for residential or industrial use, one of your primary objectives should be to maximize the area available for development. Conditions that can limit your development potential include:

- very narrow areas, especially when bounded by steep slopes or water (both of which may require buffers or setbacks);
- areas to which access is restricted by steep terrain or water; and
- depressional areas that are deep in relation to their size and thus, unattractive for development.

METHODS FOR RECLAMATION

Reclamation for a residential or industrial end use will likely involve:

- backfilling, if required, to achieve satisfactory grades for development;
- grading and contouring of the site;
- installation of drainage and erosion control measures;
- replacement of overburden and topsoil materials; and
- planting of trees, shrubs and groundcovers.

These activities should be carried out in sequence, as part of the progressive development and reclamation plan for your site.

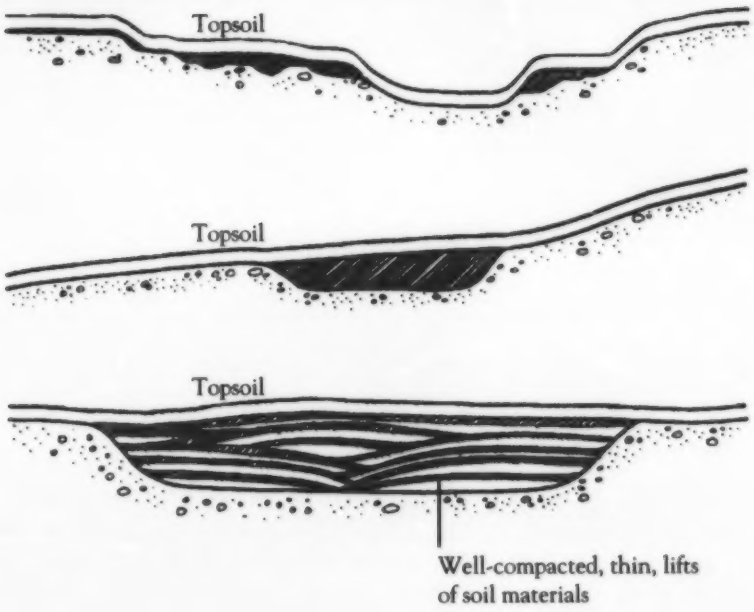


ILLUSTRATION 42,
PIT CONTOURS CAN BE MODIFIED USING OVERBURDEN FROM THE PIT OR QUARRY, OR BACKFILL FROM OTHER AREAS. FOR LARGE BACKFILLS, SOILS MATERIALS SHOULD BE PLACED IN THIN LIFTS AND WELL COMPACTED

Backfilling

Backfilling involves raising the elevation of the depleted pit or quarry floor and other proposed development areas, using overburden from your site and/or fill material from an offsite source (Illustration 42). It provides a means of raising site grades above the groundwater table, anticipated flood levels or other potential constraints to development. Depending on the overall development concept, grades may be raised across the entire property or merely in certain areas, such as individual development sites.

You should only use natural *inorganic* fill material as backfill. Ideally, this material, should be placed and compacted in thin lifts. Other materials, such as waste concrete may be suitable for use as backfill, but should be placed at depth within the fill and covered with at least 1.6 metres or more of natural fill. If deep foundation systems such as piles will be required, concrete blocks and similar debris can create installation problems. Backfill, if placed under rigorous control and compacted to specified densities, is suitable for support of light structures.

Under no circumstances should organic soil, landfill materials or domestic garbage be used as backfill material. Experience has shown that these materials break down very slowly over a long period of time, resulting in long-term settlement which will often make the site unsuitable for residential or industrial structures. Domestic garbage and other organic fill may also generate methane gas. Unless complex and costly collection and disposal systems are installed, methane can lead to long-term health and fire hazards.

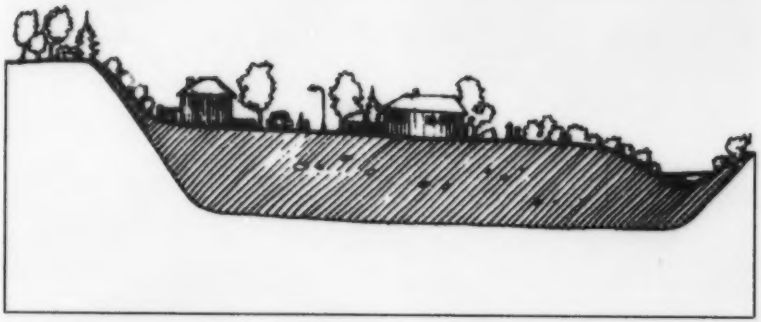


ILLUSTRATION 43, IN RESIDENTIAL AREAS, THE CONTOURS OF YOUR PIT OR QUARRY SHOULD BE BLENDED INTO THE ADJACENT TERRAIN FOR SAFETY AND AESTHETICS

Grading and Contouring

Once you have completed any necessary backfilling, you should grade and recontour your site to your design specifications. Graded contours for the pit area should blend into the adjacent terrain (Illustration 43). Your grading plan should also provide for surface and storm water drainage of the site (see below).

Development of Slopes

Under current reclamation legislation abandoned slopes must not be steeper than 4:1 (see Chapter 2). While adequate for erosion control, these slopes are too steep for any residential or industrial options; suitable slopes should be in the range of 10:1 to 20:1. These slopes can be constructed by:

- Creating gentle slopes as part of the actual mining operation (which may result in incomplete and inefficient extraction of the resource),
- Backfilling steep slopes with excess overburden or offsite fill to construct gentle slopes, or
- Cutting down steep pit walls from above to create gentler slopes.

The recommended slopes are gentle enough to be developed, yet still provide positive surface drainage.

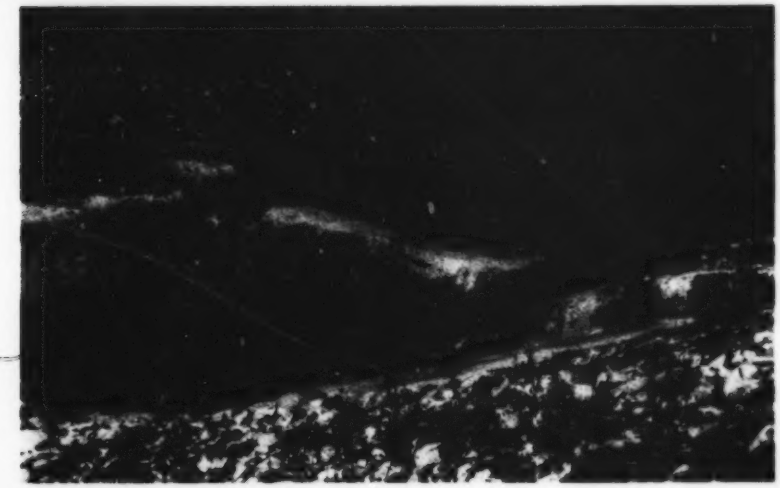


PHOTO 33, IN RESIDENTIAL AND INDUSTRIAL SITES, YOU MAY NEED TO CONSTRUCT DRAINAGE WAYS AND DEPRESSIONAL AREAS FOR STORMWATER RETENTION

Site Drainage

Due to the nature of residential and industrial developments, less bare ground is available to absorb rainfall and runoff than in natural areas. Because surface runoff may be higher, you must consider requirements for storm water drainage and control during site grading and contouring. Depending on the features of your reclamation areas, and your proposed residential or industrial use, you may need to construct swales and drainageways between development sites, as well as depressional areas to serve as storm water retention ponds (Photo 33).

Replacing Overburden and Topsoil

Overburden and topsoil replacement is the final reclamation task, prior to re-establishment of a vegetation cover. Overburden and topsoil should be spread evenly across the site (see Chapter 2). To avoid wastage of good overburden and topsoil, these materials should not be replaced in areas that are likely to be excavated, or in areas that will be flooded by water courses, ponds and wetlands. Once the topsoil has been replaced and graded, a temporary or permanent groundcover should be established to minimize soil and wind erosion.

Re-establishing Plant Cover

Your needs for re-establishing plant cover will vary greatly depending on your preferred residential or industrial land use. In residential developments and in some industrial developments, landscaping with trees, shrubs and groundcovers is generally expected as part of the development. Due to the complexity of the task, you may want to hire a qualified landscape architect to assist you in designing and implementing appropriate landscaping.

Regardless of the final use, it is important that a permanent plant cover be established in all areas of your residential or industrial development that will not be occupied by buildings, parking areas, roadways, and other structural facilities.

OTHER SOURCES OF INFORMATION

For additional information on reclaiming land for residential and industrial use, write or phone:

Land Management Branch,
Alberta Public Lands Division,
4th Floor, South Petroleum Plaza,
9915 - 108th Street,
Edmonton, Alberta
T5K 2G8
Phone: (403) 427-6597

Land Reclamation Division,
Alberta Environment,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Within Alberta, you can call either of these agencies toll free through the R.I.T.E. Telephone Network. See Chapter 10 for a listing of the R.I.T.E. Telephone Number in your area.

Additional information on reclaiming land for residential and industrial use may be available from:

The Alberta Association of Landscape Architects,
P.O. Box 3395, Station D,
Edmonton, Alberta
T5L 4J2
Phone: (403) 424-4781

Books and Reports

1. *A Guide to Site Development and Rehabilitation of Pits and Quarries*. By A.M. Bauer. 1970. Ontario Department of Mines, Industrial Minerals. Report 33. 62 pp.

2. *Sand and Gravel Operations: A Transitional Land Use*. By K.L. Schellie (editor). 1977. National Sand and Gravel Association. Silver Spring, Maryland. 211 pp.

ASSISTANCE FROM GOVERNMENT AND NON-GOVERNMENT AGENCIES

GOVERNMENT SOURCES OF TECHNICAL ASSISTANCE

Alberta Agriculture,
Conservation and Development Branch,
2nd Floor, J.G. O'Donoghue Building,
7000 - 113th Street,
Edmonton, Alberta
T6H 5T6
Phone: (403) 422-4385

Alberta Environment
Land Reclamation Division,
3rd Floor, Oxbridge Place,
9820 - 106th Street,
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6323

Water Resources Administration Division,
2nd Floor, Oxbridge place,
9820 - 106th Street.
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-6111

Alberta Forestry, Lands and Wildlife
Habitat Branch,
Alberta Fish and Wildlife Division,
2nd Floor, Bramalea Building,
9920 - 108th Street,
Edmonton, Alberta
T5K 2M4
Phone: (403) 427-9506

Forest Land Use Branch,
Alberta Forest Service,
6th Floor, Bramalea Building,
9920 - 108th Street,
Edmonton, Alberta
T5K 2M4
Phone: (403) 427-3582

Land Conservation and Reclamation Council
Main Floor, North Petroleum Plaza
9915 - 108th Street
Edmonton, Alberta
T5K 2C9
Phone: (403) 427-3582

Land Management Branch,
Alberta Public Lands Division,
4th Floor, South Petroleum Plaza,
9915 - 108th Street,
Edmonton, Alberta
T5K 2C9
Phone: (403) 427-6597

Alberta Municipal Affairs
Planning Services Division,
12th Floor, City Centre Building
10155 - 102 Street
T5J 4L4
Edmonton, Alberta
Phone: (403) 427-2190

Alberta Recreation and Parks,
Standard Life Centre, 10405 Jasper Avenue,
Edmonton, Alberta
T5J 3N4
Phone: (403) 427-2008

Alberta Tourism,
10155 - 102nd Street,
Edmonton, Alberta
T5J 4L4
Phone: (403) 427-4321

Within Alberta, you can call these government agencies toll free through the R.I.T.E. Telephone Network. R.I.T.E numbers for communities in Alberta are as follows:

Barrhead	674-8251	Cardston	653-4461
Blairmore	562-7331	Claresholm	625-3301
Brooks	362-1211	Drumheller	823-1611
Calgary	297-6161	Edmonton	427-2711
Camrose	679-1211	Edson	723-8341

Fort McLeod	553-3346	Red Deer	340-5111
Fort McMurray	743-7171	Rocky Mountain House	845-8211
Grande Prairie	538-5121		
Hanna	854-5511	St. Paul	645-6212
High Prairie	523-6561	Slave Lake	849-7111
High River	652-8311	Stettler	742-7511
Hinton	865-8211	Taber	223-7911
Lac La Biche	623-5211	Three Hills	443-8511
Lethbridge	381-5151	Vegreville	632-5461
Lloydminster	871-6411	Vermillion	853-8111
Medicine Hat	529-3511	Wainwright	842-7511
Olds	556-4221	Wetaskiwin	352-1211
Peace River	624-6181	Whitecourt	778-7111
Pincher Creek	627-3366		

If you are not within a toll free area for a R.I.T.E. operator, dial the operator and ask for Zenith 22333. You will be connected, at no charge, to the nearest R.I.T.E. Centre for assistance.

The R.I.T.E. system is also accessible by T.D.D. equipment for the deaf and hearing or speech impaired.

- In Edmonton, call 427-9999.
- Outside the Edmonton area, call toll free 1-800-232-7215.

NON-GOVERNMENT SOURCES OF TECHNICAL ASSISTANCE

Ducks Unlimited,
#302, 10335 - 172 Street,
Edmonton, Alberta
T5S 1K9
Phone: (403) 489-2002

Trout Unlimited,
P.O. Box 6270, Station "D",
Calgary, Alberta
T2P 2C8
Phone: (403) 221-8360

Wildlife Habitat Canada,
#301, 1704 Carling Avenue,
Ottawa, Ontario
K2A 1C7
Phone: (613) 722-2090